Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

FOR ALL POWER ENGINEERS • STEAM, ELECTRICITY AND ALL OTHER POWER ENGINEERING SERVICES

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The PRACTICAL ENGINEER and ELECTRICIAN

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1900 RPM Electric Generator

DECEMBER

1950

TECHNICAL PUBLISHING COMPANY • CHICAGO, ILLINOIS

They build 'em

This photograph of an Elliott 975,000-lb-per-hr vertical deaerating heater mounted on a horizontal storage tank, was made on the assembly floor with the unit under final water test of 200 psi, and before the various gages and control valves were installed.

ELLIOTT **DEAERATING**

big at Elliott

Utility companies have long been coming to Elliott Company for the biggest deaerating heaters required by their fine new stations. They know that Elliott engineers have unparalleled experience in building and applying deaerating heaters to get the most effective and efficient feedwater heating and deaerating results. *An example is the unit illustrated.*

The Elliott units going to plants both big and small now have the "new look." They no longer are encumbered with external vent condensers. Elliott has "built in" the vent condenser, making a more compact unit and one easier to maintain—two big advantages. In addition, in the new units, all interior parts exposed to possible corrosion are of stainless steel. Performance is as it always has been with Elliott units—par excellence.

Descriptive bulletin on request.

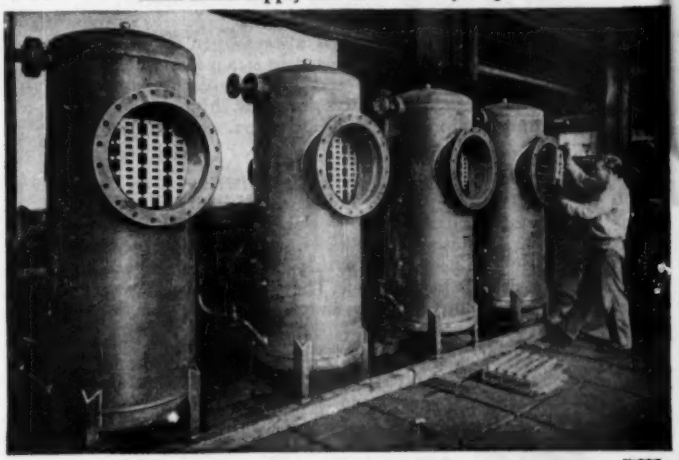
ELLIOTT COMPANY Deaerator & Heater Dept.
JEANNETTE, PA.

PLANTS AT: JEANNETTE, PA. • RIDGWAY, PA. AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.
DISTRICT OFFICES IN PRINCIPAL CITIES

This photograph shows the deaerating heater from the opposite side. At top is the relief valve opening; at bottom, the steam equalizing connection with the storage tank, and the three openings in a line are the main steam supply and the auxiliary drip returns.

...and small too

These four deaerating heaters of the new design, with built-in vent condensers, are being assembled ready for test. These units will serve as high pressure evaporator preheaters.

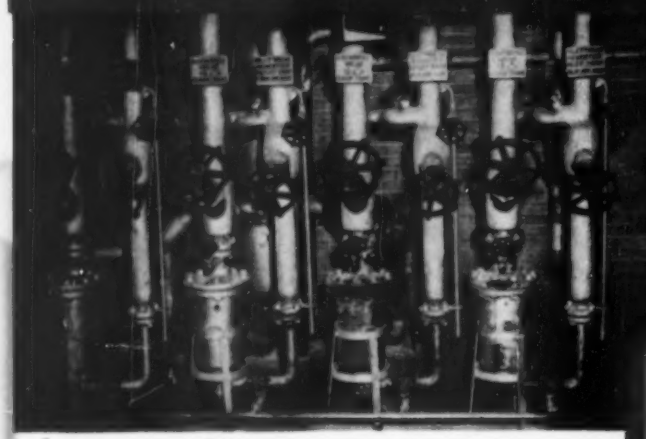


H-997

FEEDWATER HEATERS

have no tubular vent condensers

steam traps



List of Materials

CAP and BODY FORGINGS:*
Up to 600 psig—S.A.E. 1030 steel
600 to 900 psig—ASTM F-1 moly-steel
900 to 1500 psig—ASTM F-7 chrome moly-steel

VALVE AND SEAT:
Chrome steel, heat treated

BUCKET and VALVE LEVER ASSEMBLY:
18-8 Stainless Steel

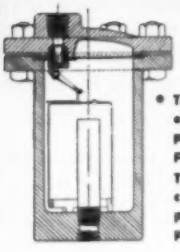
BOLT and NUT SET:*
Bolts Class C, 125,000 lbs. tensile
Nuts, hex, semi-finish, S.A.E. 1030

GASKET:*
Compressed graphited asbestos

*Does not apply to No. 3211 nor No. 913

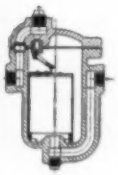
1. FOR HIGH PRESSURE SERVICE — engineers responsible for the design or operation of high pressure, high temperature steam plants can specify with confidence Armstrong Forged Steel Steam Traps to provide completely automatic condensate drainage throughout. These traps are "standard" in leading power stations throughout the entire world where they are used for draining headers, desuperheaters, soot blowers and other drip points at pressures as high as 2400 psig! These traps always open when filled with condensate and there is no steam loss under no-load conditions. Safety and dependability are assured through use of modern materials, highest quality workmanship and critical inspection.

2. FOR ALL-STEEL INSTALLATIONS — Armstrong Forged Steel Traps also ideally meet the increasing demand in power plants, refineries and general industry for all-steel fittings on lower pressures (up to 250 psig) because they are light in weight and surprisingly low in price. They provide the maximum in safety, dependability, shock and fire resistance.



- **Traps with screwed connections for pressures to 900 psig.**
  Traps with flanged connections for pressures to 2400 psig.

- **No. 3211 trap for pressures to 250 psig, only $14.00.**



- **Side inlet cast steel trap for pressures to 600 psig, screwed or flanged connections.**

FOR COMPLETE DATA ask for the 36-PAGE ARMSTRONG STEAM TRAP BOOK or see our catalog in Sweet's.

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Power Engineering

Combining POWER PLANT ENGINEERING and POWER GENERATION

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December 1950

VOLUME 54—NUMBER 12

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Notes on This Issue

National Container Plant

Here is an industrial steam-electric power plant which furnishes all the steam and electricity needed by the factory, surplus electric power to the local utility and operates in parallel with a small hydro plant to handle standby loads. It is National Container Corporation's new high-pressure plant at Tomahawk, Wis. An intensely interesting power plant story.

Static Magnetic Regulators

A clear, complete description of a most interesting device. As the name implies, this regulator has no moving parts whatever. It is small, compact, instantaneous in response and many electrical engineers acclaim it as a really fool-proof voltage regulating system. We published an article by Mr. Hunter last March on the "Maintenance of Static Magnetic Regulators" but as usual you power engineers want to know the "how" and "why" so in response to your letters we present this second article telling exactly what these devices are, how they are made, how they work and what they can do.

19,000 Rpm Generator

The picture on the front cover is Dr. Strough working on an interesting experimental development at Case Institute of Technology in Cleveland. The generator is based on the Faraday disc principle but operates at extremely high speeds to build up large amounts of kinetic energy, which is converted into pulses of electric current, having values as high as 50,000 amperes.

Fuel Cost Under 2 Mills

A saving of $20,000 per year is important in any man's plant. This article tells how the installation of a new 1420 hp Dual-fuel Fulton engine and conversion of existing diesels to natural gas accomplished that saving in the Cushing, Oklahoma, Municipal Power Plant.

Vast Hydro-power in Scotland

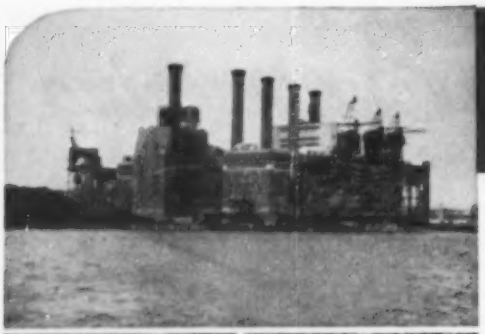
There's a lot of rain in the Scottish Highlands and the canny Scots are taking advantage of their super-rainy spells by a tremendous hydro-electric power development. The present plan involves 102 hydro projects capable of an annual production of over six billion kilowatt hours. So far 19 projects have been developed with a capacity of 630,000 kw. This article not only gives a good over-all picture of the development but also interesting detail on the Lock Sloy dam which was opened by Queen Elizabeth last month.

Practical Engineer Section

One of the especially interesting items this month is on "Superheater Tube Failures." Engineers frequently find such failures when they know tubes are clean. One of the principal causes is incorrect boiler operation allowing the superheater tubes to get too hot. This article points out the differences in operating requirements between boiler tubes and superheater tubes and explains how to operate the boiler and control the drain valves to avoid this type of tube failure.

Another P. E. & E. article tells "How to Space Pipe Supports Correctly." It deals with the very practical problem of locating pipe supports to pitch the pipe properly to attain drainage. The data needed is expressed in chart form which saves the busy engineer a lot of mathematical calculations.

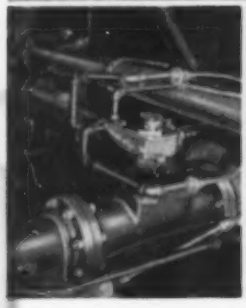
The series on "Basic Power Plant Figuring" seems to be growing rather famous, judging by the correspondence it creates. This month Mr. Engleman goes into the mathematics of coal buying — how to buy it by the million Btu rather than the ton. In order to buy heat instead of weight the engineer must take into account such factors as fusion temperature of ash, amount of ash and sulphur in the coal and must know how to analyze samples. The author has worked up a convenient table for determining heating value and there is a great deal of other useful information about coal buying in this article.

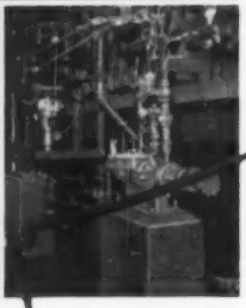


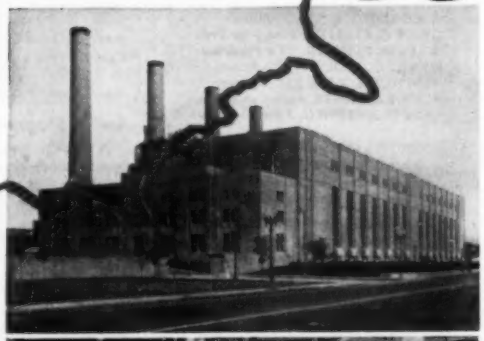
Chemical Treating Equipment for Boiler Water Conditioning

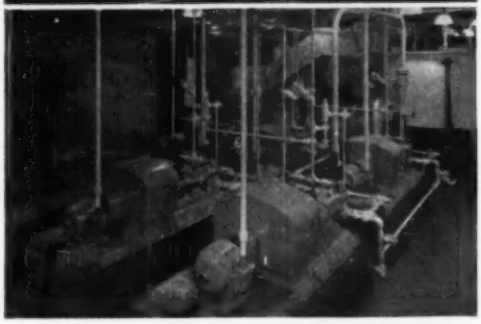
Used by Major Power Plants

Across the Country









From coast to coast, %Proportioneers% Chemical Treating Equipment provides modern power plants with an adequate and regular method for treating boilers automatically and in proportion to their service loads. A *necessity* in *large* plants, the %Proportioneers% system also offers many advantages in *small* plants to reduce manpower and give adequate protection.

For the largest high pressure installation or the smallest low pressure job, %Proportioneers, Inc.% can supply feeders, controls, chemical tanks, dissolvers and auxiliary equipment as required—a single responsibility for your complete feeding problem.

Write for Brochure SM 9020
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No. 4 in a series on boiler water conditioning.

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ENGINEERS' PREVIEW

NEW CAUSTIC SODA and chlorine plant, constructed with American engineering "know how," has increased the production capacity of caustic soda in India almost 20 per cent.

The plant, now operating at capacity, was designed and built by The H. K. Ferguson Co. for Delhi Cloth & General Mills, Ltd., at Delhi. Financed in its entirety by Indian interests, it is the only plant in northern India which produces chlorine, caustic soda and hydrochloric acid, and is 900 miles distant from the nearest plant of its kind at Calcutta.

Small by U.S. standards, the new plant has an annual capacity of 2100 tons of caustic soda, which represents a sizeable portion of India's estimated 12,000-ton output in 1950. The remainder of the 43,000 tons required annually in India is imported principally from the United Kingdom and the United States.

Almost half of India's caustic soda consumption is devoted to the production of soap. A fourth of it is used in the textile industry, and the remainder is taken by paper mills, oil refineries and miscellaneous other industrial concerns. Chlorine is used primarily in the manufacture of paper and textiles and by water works for purification purposes. Relatively large quantities of hydrogen gas are used for the manufacture of "vanaspati," a type of cooking fat popular in India.

The new plant, known as D.C.M. Chemical Works, will supply these products to industrial interests throughout northern India, where caustic soda is in particularly short supply.

★ ★ ★

RELATIVELY NEW, but increasingly important use of large scale electric power, and the necessity for reliability of power supply in oil refining were described at the Fall General Meeting of the AIEE. In a technical paper entitled, Automatic Control of Metal Clad Switchgear Serving Oil Refinery Motors During Power System Disturbances, four engineers described apparatus for insuring continuous power in refining operations. They stressed the industry's "gradual change of viewpoint with regard to reliability of electric power vs. steam," and pointed out that outages of even a few minutes can have costly repercussions at a refinery.

A 4-min. outage on a delayed cooking unit at a Toledo refinery, for instance, results in a three-day shutdown, while a 10-min. outage at Sohio's Lima, Ohio, refinery would cost about $30,000, they said.

The oil refiner's use of electric drive for blowers, pumps, fans and compressors is increasing rapidly due to several basic causes, the authors pointed out. First it is possible to generate his steam requirements at high pressure and to top the process steam through non-condensing turbine generators, thereby producing electrical energy with about 4500 Btu per kwhr. Second, it is possible to purchase electric energy for around 6 to 10 mills per kwhr in many refinery locations. Electric power drive compares very favorably when the factors of labor, maintenance, supervision and return on investment are considered. Rapid process developments utilizing new drives, continuously present opportunities to improve efficiency in the use of energy. Necessity for minimizing the use of water also is a factor, permitting refinery expansion that might not otherwise be possible.

WANT TO BUILD AN ATOMIC PILE?

NOW YOU CAN build an atomic reactor. As announced in many newspapers recently, on November 24th the U. S. Atomic Energy Commission released all of the basic details of construction on the low-power research reactors at the Argonne National Laboratory and of the light water enriched reactor at Los Alamos. You will find all the details in the Nov-Dec issue of ATOMICS magazine, which many of you may recall started as a section of *Power Engineering*.

Here, for the first time, you will find the answers to all the questions you have been wondering about ever since the Smyth report was released five years ago. You will find out how big the reactors are, how many tons of uranium were used, how many tons of carbon, how much heavy water. It will tell you exactly how large the carbon blocks were, how they were arranged and how many layers there were. You will also find details of the mechanical arrangement for controlling the operation of the reactors, what materials were used in the controls. The safety arrangements, also, are explained in detail.

For the first time you will also learn the exact cross section of thermal neutrons for fission, absorption, and scattering for the isotopes of uranium and for natural uranium. In fact, with the data given you would have no difficulty in building a nuclear reactor yourself, provided you could get hold of some 50 tons of uranium or 6 or 7 tons of heavy water—*and*, last but not least, permission from the government to use the fissionable material. Remember, it's all in this issue of ATOMICS.

★ ★ ★

PLANS UNDER WAY to celebrate the ASCE Centennial of Engineering in Chicago in 1952 were announced by the Board of Direction at its Toronto Meeting. The project will provide opportunity for American industry to emphasize its contributions to the advancement of civilization and to pay tribute to the free enterprise system that has made this progress possible. In addition to civil engineering, the celebration will include the entire engineering field, with the other societies joining forces to produce an event of international significance.

Maj. Lenox R. Lohr, president of the Chicago Museum of Science and Industry, has been elected president of the not-for-profit corporation, Centennial of Engineering, 1952, Inc., which has been set up to carry out the project and direct the over-all activities connected with it.

The celebration, including an exposition and a convocation of engineers, will occupy the approximate period July 1 to September 30, 1952, and will be centered in the Museum of Science and Industry in Jackson Park, Chicago. Already housing the world's greatest collection of industrial and science exhibits, the museum is ideally adapted to the objectives of the celebration.

HOW ELECTRICAL engineers are assisting the medical profession by developing devices to measure body conditions, was reported recently before the AIEE. An instrument to obtain more detailed information concerning the functions of various parts of the circulatory system by directly measuring the pressure of the blood within the heart and the blood vessels, has been devised to perform the measurements.

A plastic tube, called a catheter, is introduced through a hypodermic needle into the vessel under study. The instrument end of the catheter is led to a small chamber, one wall of which is a thin metal membrane, spaced a short distance from a fixed metal plate, thus forming a capacitance. Pressure changes at the end of the tube in the blood vessel are transmitted by a liquid back to the movable membrane. The varying membrane capacitance is measured by a high-frequency bridge, whose unbalance voltage, after amplification, produces a graphical record of blood pressure against time. Several new or improved instruments for measuring skin and body temperatures also were reported.

★ ★ ★

TALC PARTICLES, 35 times smaller than can be seen by the human eye, are being produced by the Gouverneur Talc Co. in upstate New York. This plant, completely powered by General Electric equipment, is turning out 200 tons of talc a day to meet the needs of paint, ceramic, and cosmetic manufacturers, as well as other industries which use talc as a filler.

The talc is reduced to micron and submicron sizes in an air-powered pulverizing mill. The most unusual feature of the mill is the lack of moving mechanical parts. Crushed rock enters the mill through a venturi-injection system, and is picked up by blasts of hot compressed air and set in motion. Talc particles in the mill circulate at a very high velocity. Under the furious agitation of the jets of air, the fast moving particles bombard each other causing almost complete disintegration.

Although there are only a few pounds of talc in the mill at any time, the speed is so high that as much as 6 tons will pass a given point in one minute. Each time a particle circulates about the chamber it becomes smaller, and it may require as many as 1500 to 2500 round trips before it reaches the proper size.

★ ★ ★

INDUSTRIAL EMPLOYEES and engineering students will be taught how to market the products of industry in new marketing and research courses to be given by the Graduate School of Stevens Institute of Technology this fall. With more than 50 cents of every consumer dollar going to distribution, it is vital to the economy to find the most efficient methods of distribution, just as engineers have increased efficiency in production through time studies and other methods, it was explained recently by Professor Calvin H. Brainard, of the Stevens faculty, who planned the courses.

"It is logical to expect," Professor Brainard said, "that through the efforts of engineer graduates so trained, the standard of living will be raised and the economy gradually benefited by increased efficiency and better management in marketing, less waste, more and better goods and service, and lower costs."

Most of the classes will be given in the evening by full-time faculty members or lecturers connected with related businesses. There will be some day-time classes open to advanced undergraduate students as well as graduates.

OF UNUSUAL INTEREST to specifiers, buyers and users of valves, is a new Manual of EQUIVALENT VALVES, just compiled by H. Gordon Hawes. This Manual embraces 175 pages of data on Equivalent Valves, listing the valves of 18 leading manufacturers. All information has been checked by each of the manufacturers. This listing shows which valves are equivalent, and the design and variations, and is intended as a ready reference for engineers, purchasing agents and engineering personnel who develop specifications or make purchases of valves.

The advantages of this new manual are quickly apparent because basically it is a guide to the differences between the valves of these 18 manufacturers for a given type, material, and pressure rating. In case a certain valve is in short supply or unobtainable, the listing shows which other valves are equivalent. Also when purchasing on an "or equal" basis, one may determine which valves are equal or equivalent.

For instance, an engineer interested in obtaining a 150 psi iron body, O.S. & Y. gate valve turns to a given page and finds all the valves the manufacturers offer to that specification, with the individual variations in the standard design features such as Bronze or Steel Stems, Bolted or Clamp Bonnets, Integral or Renewable Seats, etc. Similarly the purchasing department may find like information for their guidance in obtaining bids. The Manual is also of invaluable aid to the sales department when quoting on an "or equal" basis on valve specifications. The volume is well-indexed to enable the user, in the matter of seconds, to quickly locate the desired information. If you're interested, ask the E. P. Editor how to get one. It costs $15.00 a copy.

★ ★ ★

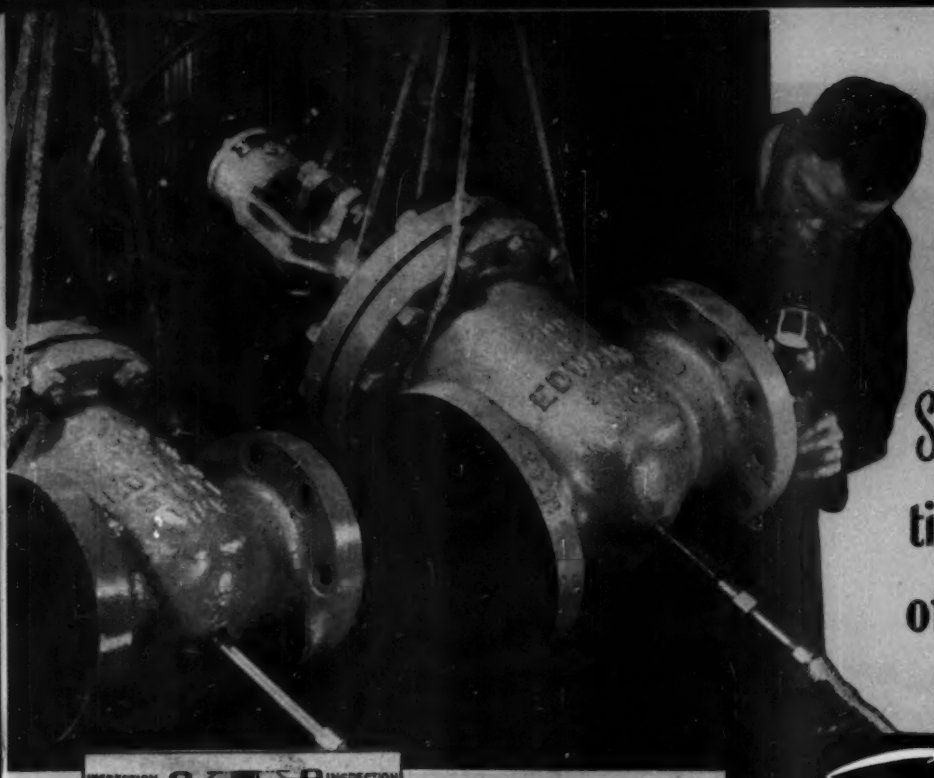
FIRST of the nation's all-purpose synthetic rubber plants to be reactivated under the government's expanded rubber program started production, October 13, 1950, ahead of schedule by 20 days. The huge plant, designed with a production capacity of 60,000 long tons a year, has been thoroughly modernized by engineers of United States Rubber Co. so that it will produce more than 72,000 long tons a year when operating at peak load.

Reactivation and modernization were accomplished in less than three months at a cost of $1,030,000, of which $530,000 was for modernization and $500,000 for actual reactivation. Modernization was accomplished at much less cost than would have been required if improvements were made after the plant was in operation.

Every valve, tank, reactor and a maze of piping was torn down, cleaned, inspected and finally reassembled. New metering equipment was installed to improve the handling of raw materials. New pumps were installed to increase the plant's capacity for handling raw materials and to improve efficiency in handling latex. Piping systems throughout the plant were simplified. Laboratory facilities were expanded and modernized to maintain better quality control, and new equipment was added to improve the recovery of raw materials.

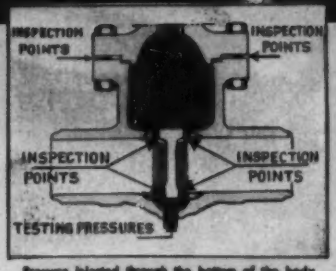
★ ★ ★

ALLIS-CHALMERS MANUFACTURING CO. has signed contracts to insure pensions for 29,900 employees. The pension contracts became effective September 1. Bankers Life Co., the underwriters, announced that the contracts were on a deposit administration basis providing pensions for more than 19,000 employees in collective bargaining units and 10,900 employees not in bargaining units.



EXCLUSIVE TEST METHOD PROVES *Simultaneous* tight seating of both faces of

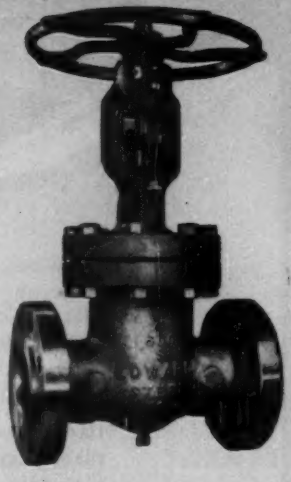
Edward GATE VALVES



Pressure injected through the bottom of the body surrounds seats, yet leaves both ends open for simultaneous inspection in Edward testing method.

Arrows show where Edward cut clearances between wedge and guide ribs to eliminate wedge drag on seats. With Edward gate valve, partial turn of handwheel transfers load from seats to wedge guides.

Edward gate valve wedge guides are welded to body after seats are in place; therefore seating parts are accurately located. Seat rings are also welded in to prevent leakage between seats and body.



When Edward engineers began the design of a new series of steel gate valves, they tested other makes. Many of them were tight on one seating face or the other, but few were tight on both faces.

To build really tight gate valves, Edward engineers discarded the conventional method of casting guide ribs as part of the body and instead developed a new technique for welding the ribs into the body *after the machined seating faces were in place*. This, they demonstrated, reduced machining tolerances, eliminated wedge drag on the seating faces, and cut wear. They were also sure it meant a tighter valve.

But how to prove it? The result was the testing method shown above. Now, *all* Edward gate valves are tested with both ends open for simultaneous inspection, and both seating faces must be tight simultaneously.

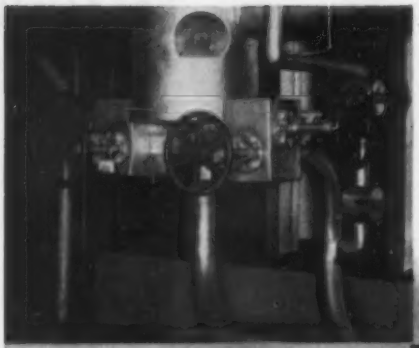
The new Edward gate valves incorporate many other plus-value features, such as welded-in seats, one-piece bonnets, ball bearing yoke bushings in most sizes, and Stellite faced seating surfaces. With Edward, these features are standard construction.

For more details write for Catalog 12-E.

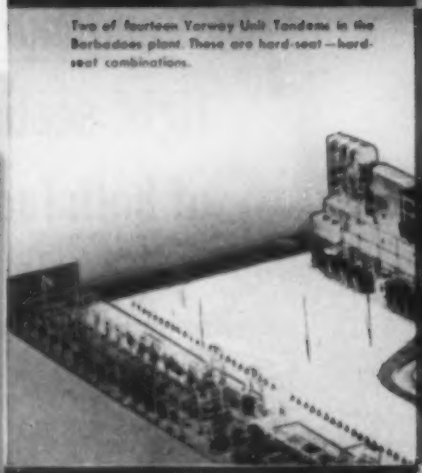
Edward Valves, Inc.

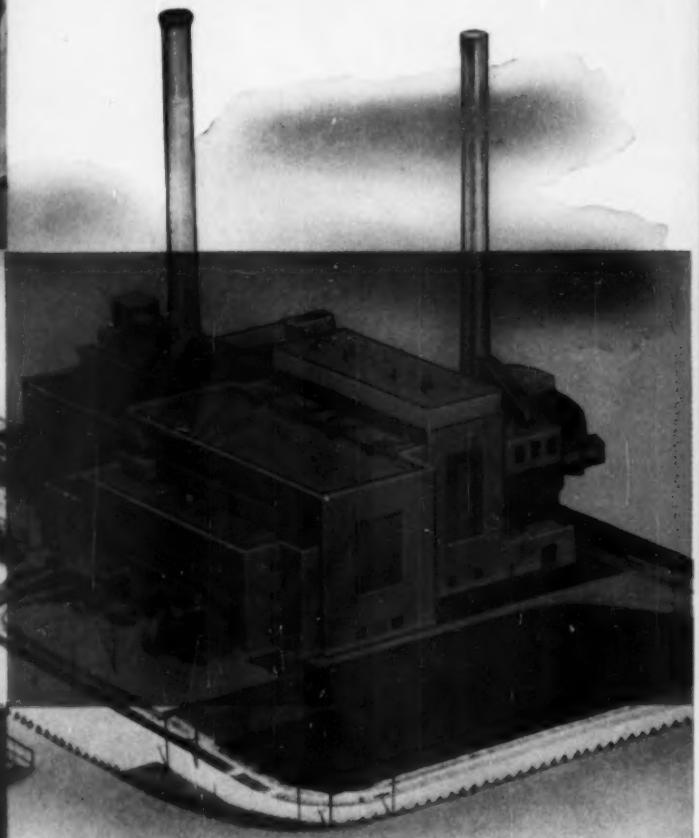
SUBSIDIARY OF ROCKWELL MANUFACTURING CO. EAST CHICAGO, INDIANA

BARBADOES BOILERS GET



Two of fourteen Yarway Unit Tandems in the Barbadoes plant. These are hard-seat—hard-seat combinations.





Yarway Unit Tandem valve sectioned through seatless (sealing) valve.

Yarway Unit Tandem valve sectioned through hard-seat (blowing) valve.

■ When a company has a $25,000,000.00 stake in the future such as Philadelphia Electric Company does in its Barbadoes Station—then protects the boilers of that plant with Yarway Unit Tandem Blow-Off Valves—it's significant of the dependability of those valves.

Barbadoes is a fine example of modern power plant engineering, demonstrated by the fact that only 11 men per shift are needed for operating this 180,000 KW station.

YARWAY

Unit Tandem Protection

Yarway Unit Tandem Blow-Off Valve, with hard-seat (blowing) valve and seatless (sealing) valve.

Yarway Unit Tandem Blow-Off Valves also are a good example of steam equipment engineering—used in more than 4 out of 5 high pressure boiler plants in the country.

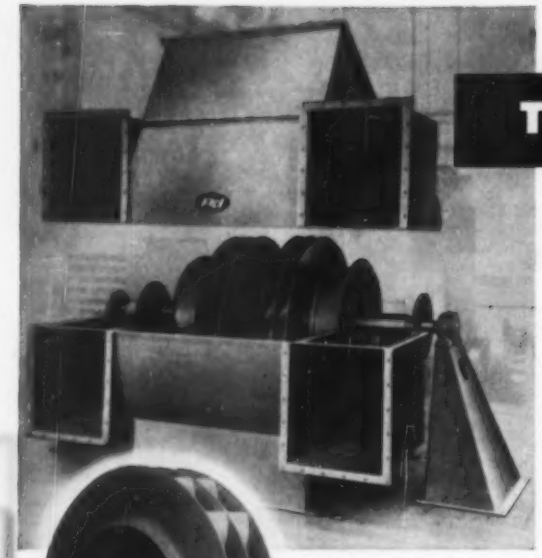
Rugged construction makes Yarways strong and tough enough to withstand severest blow-down conditions. Metallurgical improvements make them resistant to the reactions of periodic acid wash. *Outages are rare where Yarway boiler valves are used.*

Unit tandems are available in various combinations to meet all pressure and service requirements.

Write for Bulletin B-433 for full details on Yarway Unit Tandems. For lower pressure blow-off valves, write for Bulletin B-424.

YARNALL-WARING COMPANY
114 Mermaid Avenue, Philadelphia 18, Pa.
BRANCH OFFICES IN PRINCIPAL CITIES

STEAM PLANT EQUIPMENT



TWO MORE P-D

AN F-D FAN THAT PROVIDES . . . 1

- *Transfer of more kinetic energy to static pressure*
- *More effective aerodynamic flow*
- *Lower horsepower requirements*
- *Appreciable reduction in fan noise*

An unusual combination of research facilities, and the best fan design talent of several countries,* are responsible for the development of P-D Forced Draft fan.

Peak efficiency and horsepower curves fall within normal fan selection ranges, providing optimum efficiency with non-overloading characteristics.

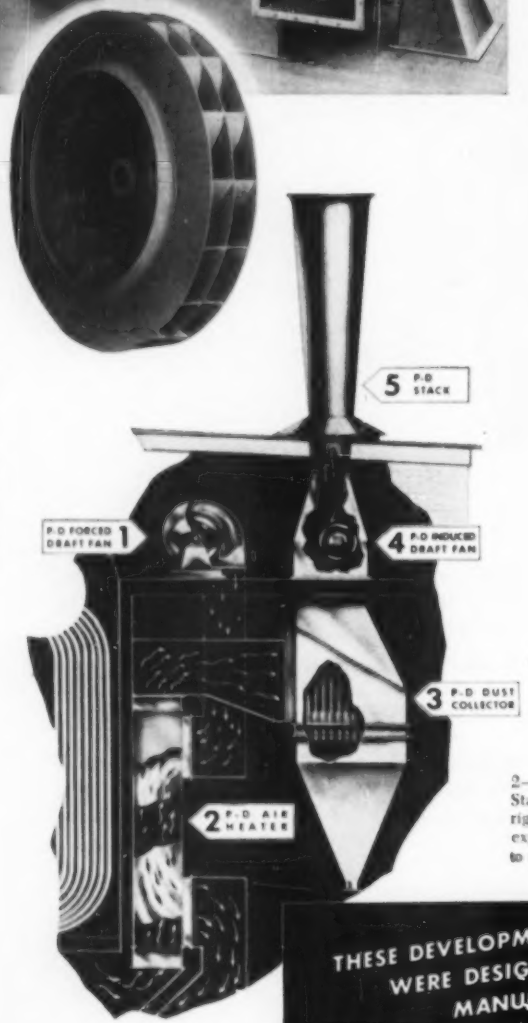
Improved diffusion from wheel to outlet permits a more complete conversion of kinetic energy to static pressure.

A backward curved, specially designed blade offers a more nearly perfect aerodynamic flow on both the leading and trailing surfaces, reducing eddy currents.

A larger, deeper inlet cone provides a smoother flow at the inlet, increasing over-all efficiency.

This new fan has been tested according to Standard Test Codes of the N.A.F.M. and the A.S.H.V.E. Write our project and sales engineers for the new bulletin No. *300* on this F. D. Fan.

*Prat-Daniel Experimental Laboratories, East Port Chester, Conn., The Baltco Fan Works in Sweden, Prat-Daniel (Stanmore) Ltd., in Great Britain and Societe Prat-Daniel of France.



UNDIVIDED RESPONSIBILITY

The illustration at left shows the 5 major boiler plant auxiliaries now built by Prat-Daniel; 1—F-D Fans, 2—Air Heaters, 3—Dust Collectors, 4—I-D Fans and 5—Fan Stacks. . . . In short, the equipment to handle the air-gas stream right through the plant, may now be purchased from a single experienced source, with the economies and advantages inherent to such responsibility.

THESE DEVELOPMENTS WERE DESIGNED AND MANUFACTURED BY: **PRAT-**

CONTRIBUTIONS TO EFFICIENCY

THE DECANTATION PROCESS . . . 2

A single stage, P-D Tubular Dust Collector, arranged to permit re-firing of high carbon dust without total re-circulation of flyash.

The well-known law, based on the inertia of a mass traveling at high velocities, suggested the design of an apparatus for separating large particles of high carbon content from flyash, for re-injection.

This is accomplished in a *single unit* by the P-D process of Decantation.* As the word implies, this collector literally pours off the larger particles into a hopper for re-firing, permitting the finer particles to enter the P-D tubes for precipitation and disposal, as shown in the illustration. Tests have proven that up to 40% of flyash from spreader stokers is generally suitable for re-injection. To obtain the best results from re-injection, and prevent the non-combustible particles from overloading, causing erosion and poor combustion, it is desirable that these particles be removed from the system.

Cut at lower right shows the space this P-D Decantation Collector requires in comparison with a standard unit. The Decantation unit actually occupies *less* area, (slightly more height), requires no more draft than is necessary to operate a standard tubular collector.

Our Project Engineers will be glad to send you this latest Bulletin No. 260D describing this apparatus.

*Pat. applied for.

Comparative size

PROJECT AND SALES ENGINEERS

THE THERMIX CORPORATION

GREENWICH, CONN.

Canadian Affiliates T. C. CHOWN, LTD., 1440 St. Catherine Street W., Montreal 25, Quebec
50 Abell St., Toronto 3, Ontario

DANIEL CORPORATION

EAST PORT CHESTER, CONN.

Milestones of engineering

The modern Foster Wheeler Steam Generator, heart of many of the most efficient central station and industrial power plants in America and elsewhere, reflects the engineering and production ingenuity of an organization long recognized as a pioneer and innovator in the field of steam generation.

The story of Foster Wheeler achievement is best revealed by the following milestones of engineering progress:

1898—Aero pulverizers firing various fuels applied successfully on a commercial scale.

1902—Superheated steam introduced commercially in the United States.

1904—Convection superheaters standardized with cast iron, extended surface rings applied to steel tubes. Bare tubes later used with improved design technique and improved metal selection.

1912—Air preheaters of tubular type built and operated. Plate type heaters followed a few years later.

1917—Water tube boilers designed for production on a large scale—both oil and coal fired.

1919—Economizers of high pressure, extended surface, unit type introduced.

1919—Radiant superheaters developed after long research and experimentation.

EXPERIENCE...the priceless

progress

1924—Water walls and water backs applied to many types of furnaces burning various fuels.

1934—Pulverized anthracite burned in direct-fired system eliminating need for pulverized fuel storage.

1935—Radiant reheaters and radiant superheaters installed in one of the first large high pressure reheat units in the country.

1936—Twin furnace steam generators of the separately-fired superheater type (shown upper right) developed to give steam temperature control over load ranges up to 10 to 1.

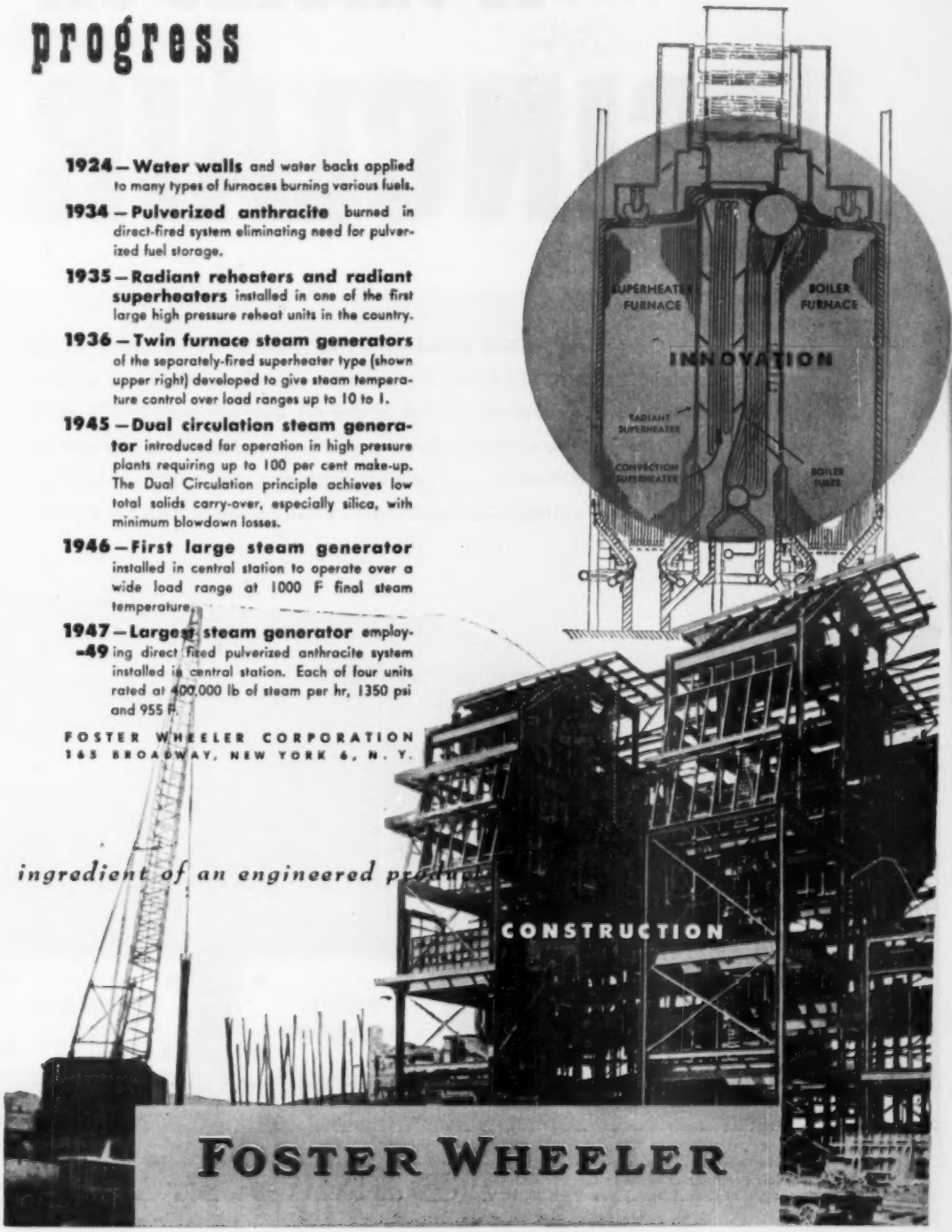
1945—Dual circulation steam generator introduced for operation in high pressure plants requiring up to 100 per cent make-up. The Dual Circulation principle achieves low total solids carry-over, especially silica, with minimum blowdown losses.

1946—First large steam generator installed in central station to operate over a wide load range at 1000 F final steam temperature.

1947—Largest steam generator employing direct fired pulverized anthracite system installed in central station. Each of four units rated at 400,000 lb of steam per hr, 1350 psi and 955 F.

1949

FOSTER WHEELER CORPORATION
165 BROADWAY, NEW YORK 6, N. Y.

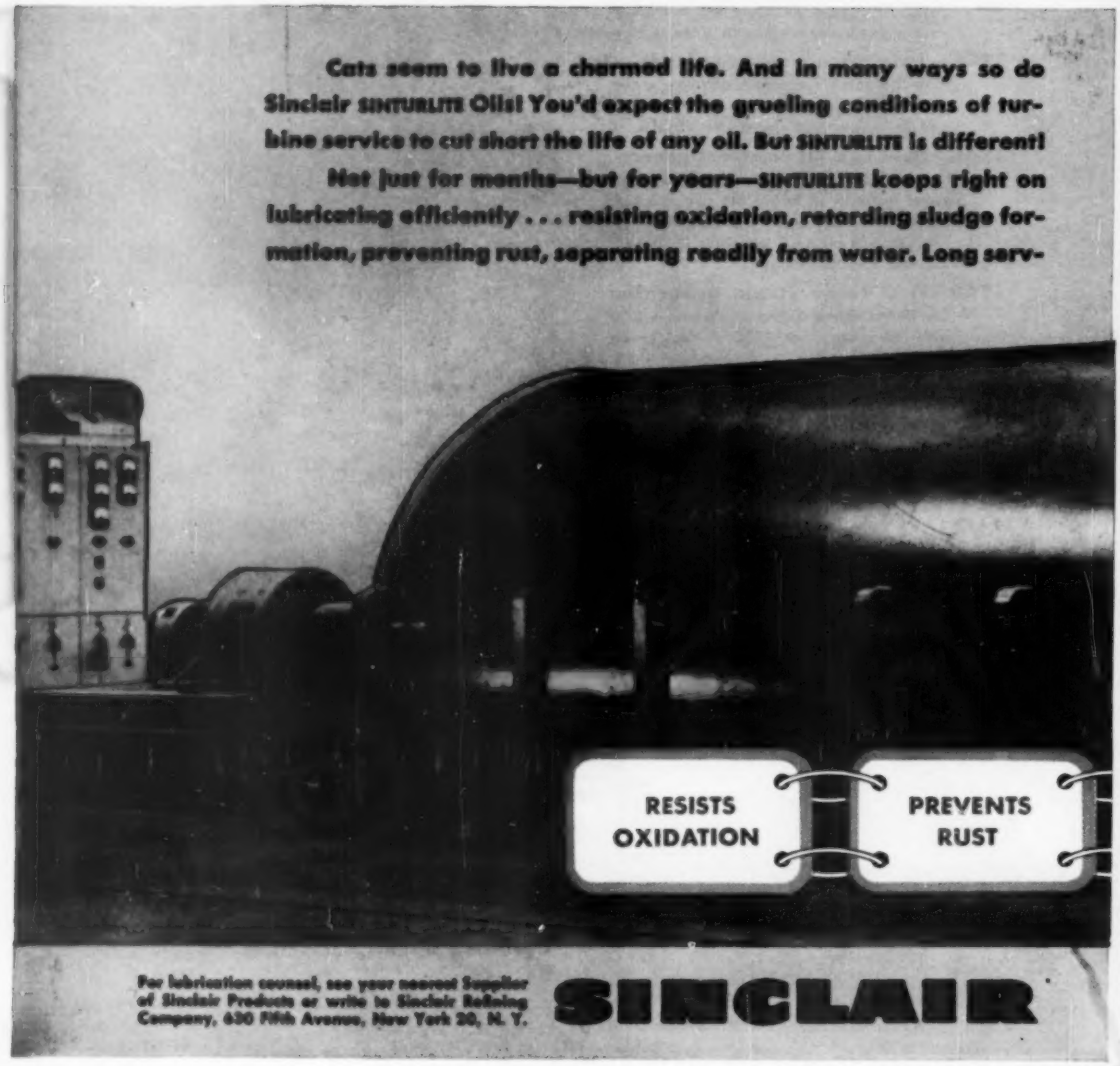


ingredient of an engineered product

FOSTER WHEELER

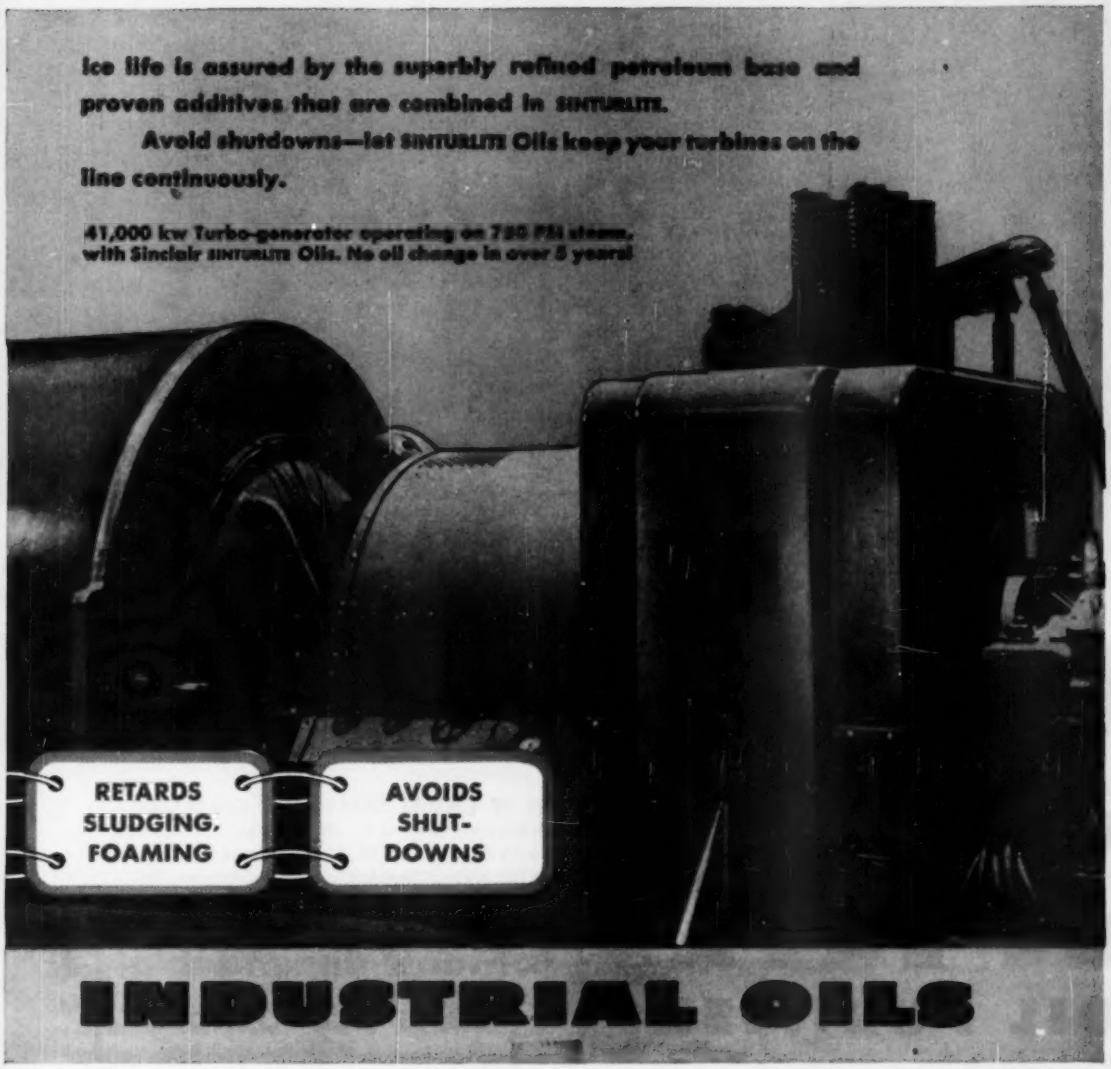
A turbine oil

SINCLAIR


Cats seem to live a charmed life. And in many ways so do Sinclair SINTURLITE Oils! You'd expect the grueling conditions of turbine service to cut short the life of any oil. But SINTURLITE is different!
Not just for months—but for years—SINTURLITE keeps right on lubricating efficiently . . . resisting oxidation, retarding sludge formation, preventing rust, separating readily from water. Long serv-
RESISTS OXIDATION
PREVENTS RUST
For lubrication counsel, see your nearest Supplier of Sinclair Products or write to Sinclair Refining Company, 630 Fifth Avenue, New York 20, N. Y.
SINCLAIR

with nine lives...

SINTURLITE


ice life is assured by the superbly refined petroleum base and proven additives that are combined in SINTURLITE.
Avoid shutdowns—let SINTURLITE Oils keep your turbines on the line continuously.
41,000 kw Turbo-generator operating on 750 PSI steam, with Sinclair SINTURLITE Oils. No oil change in over 5 years!
RETARDS SLUDGING, FOAMING
AVOIDS SHUT-DOWNS

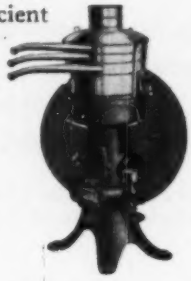
INDUSTRIAL OILS

WHIRLING MILESTONES

De Laval today offers a centrifuge for every purification need in the power field. Back of every recommendation stands nearly three-quarters of a century of being *first* in major centrifugal developments.

1878 Carl Gustav De Laval invented the first continuous Cream Separator. He tried tubular bowl design.

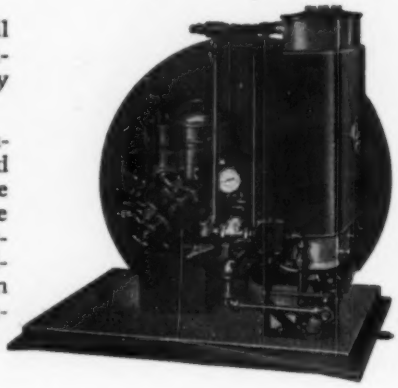
1890 Dr. De Laval abandoned tubular bowl, invented slower-speed disc bowl to stratify liquid for more efficient purification.



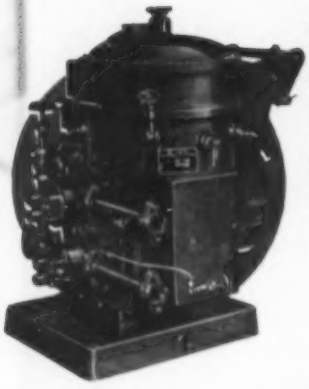
1918 First centrifugal Oil Purifier introduced by De Laval. This continuous Oil Purifier was driven by a small steam turbine.

1922 First De Laval centrifugal Insulating Oil Purifier installed. In 1950, the centrifuge is still the safest way to maintain insulating oil because water, once discharged, cannot recontaminate the dry oil.

1950 Full range of "Uni-Matic" Oil Purifiers now available, including No. 67 with a capacity of approximately 450 gph.



De Laval "Puri-Filter," combining centrifugal force and filtration, makes possible the removal of fly ash or moisture haze as well as more dangerous impurities. The "Puri-Filter" is the ultimate in turbine or engine oil lubrication purification.

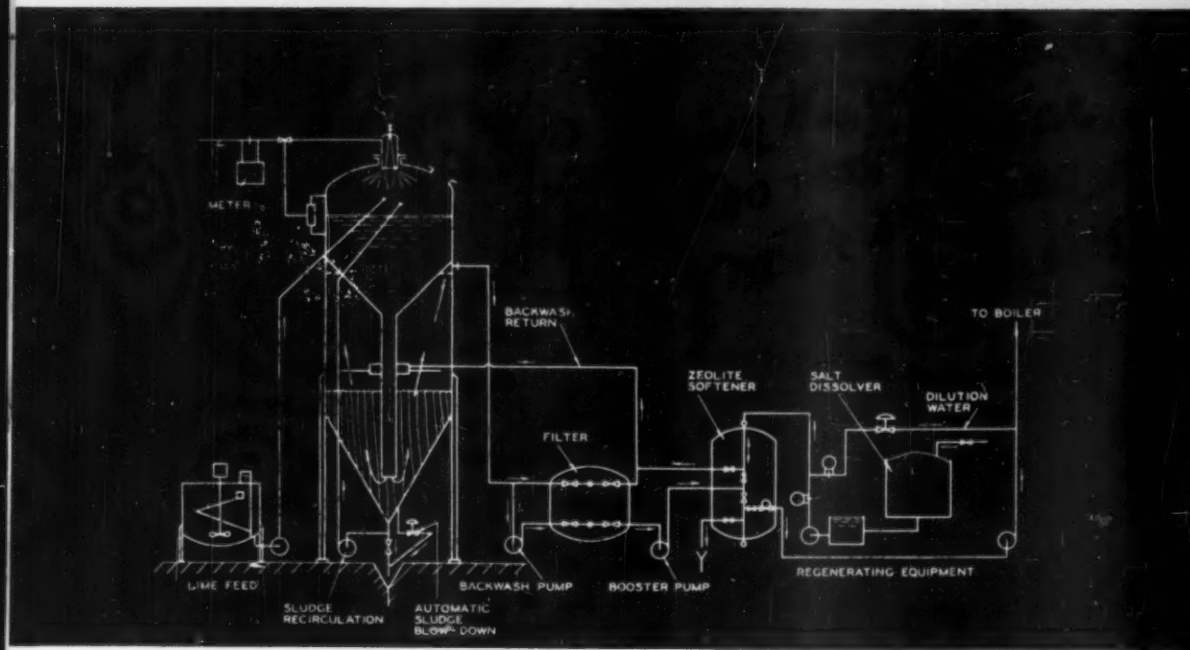


THE DE LAVAL SEPARATOR COMPANY
165 Broadway, New York 6 427 Randolph St., Chicago 6
DE LAVAL PACIFIC CO., 61 Beale St., San Francisco 5
THE DE LAVAL COMPANY, Limited, Peterborough, Ont.

DE LAVAL OIL PURIFIERS

for most dependable power production

cochrane hot process zeolite water conditioner



1. saves chemicals
The zeolite softener uses salt instead of the more expensive soda ash and phosphates, bringing down the cost of chemicals considerably.

2. saves on capital investment The cost of adding zeolite equipment to a hot process installation is far less than the addition of an independent sedimentation tank and chemical feed for a two-stage phosphate process.

3. lower CO_2 in steam
The lower alkalinity resulting from using lime alone, plus the fact that this alkalinity is all carbonate, causes a reduction in CO_2 generated in the steam.

4. less operating attention The use of the zeolite softener with its simplicity of operation is an advantage which is enhanced by the longer periods between regenerations, due to the lower hardness of the hot process softener effluent.

5. less floor space and head room required
The addition of the zeolite equipment requires less floor space and less head room than that required for two stage phosphate equipment.

6. lower alkalinity The use of lime (or Dolomitic lime) as the sole reagent in the hot process means that the alkalinity can be reduced to about half that obtained with lime and soda ash.

7. only one chemical needed in the hot process It is generally possible to use a single reagent in the hot process, namely lime or Dolomitic lime, precipitating the bicarbonates and magnesium, leaving the remaining hardness to be removed by the more economical zeolite.

get the facts about this economical process use this coupon

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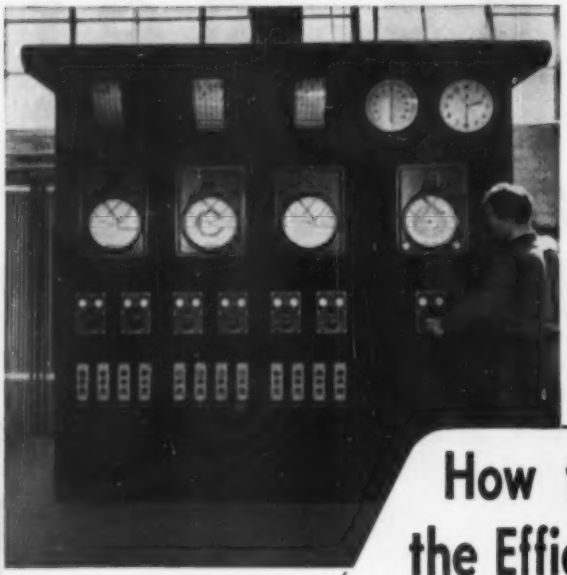

These Bailey Boiler Controls at the Chicago Pneumatic Tool Company's new plant in Utica, N. Y. insure efficient operation of three 25,000 lb per hour, 100 psi, spreader stoker-fired boilers

How to INCREASE the Efficiency of YOUR BOILER-ROOM DOLLAR

Before you get steam you've got to spend dollars—so dollars are a form of energy.

And if your boiler-room dollars are invested in equipment that isn't working efficiently, economically, your "investment" is poor.

That's where co-ordinated controls by Bailey can help. Here's why they'll increase your "boiler-room investment efficiency":

1. **Complete Range of Equipment—fully co-ordinated.** You need never worry that a Bailey Engineer's recommendation is slanted in favor of a particular type of equipment, just because he has a limited line to sell—or that Bailey will pass the buck for efficient control; we offer *complete* boiler control systems.

2. **Engineering Service—backed by experience.** No other manufacturer of instruments and controls can offer as broad an experience, based on successful installations involving all types of combustion, flow measurement and automatic control.

3. **Direct Sales-Service — conveniently located near you.** Bailey Meter Company's sales-service engineers are located in more industrial centers than those of any other manufacturer of boiler control systems; you get prompt, experienced service with a minimum of travel time and expense.

•

For better "boiler-room investment" efficiency —for more power per fuel dollar, less outage and safer working conditions, you owe it to yourself to investigate Bailey Controls. Ask a Bailey engineer to arrange a visit to a nearby Bailey installation. We're proud to stand on our record: "More power to you!"

A-111-0

BAILEY METERS

BAILEY METER COMPANY

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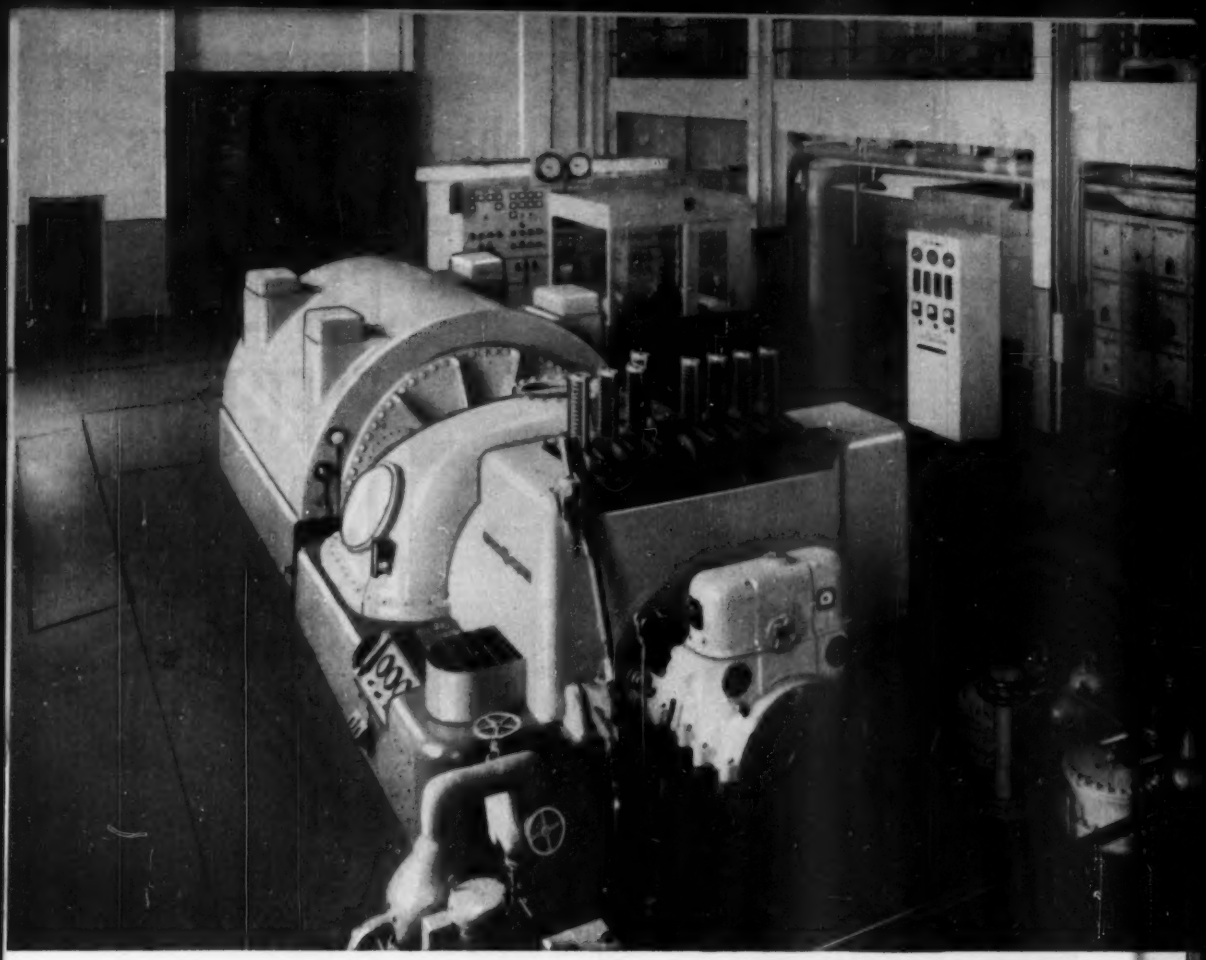
Controls for Steam Plants



New turbine is slated for trouble-free life

IN 1949 when this 21,000-KW turbine was put in operation in a midwest power company, officials saw no problem in keeping maintenance at a rock-bottom low. Experience covering 16 years' operation convinced them that they had the answer—NONPAREIL Turbine Oil. They had already put NONPAREIL into three 5,000-KW units—in 1933, in 1935, and in 1940, respectively.

To this day the oil in these units has not been changed, yet there have been no oil-deterioration troubles, no deposit troubles, no high-acidity troubles. In fact oil neutralization numbers have remained below 0.10 mg. KOH/gm.

Consider that record as applied to minimizing your maintenance and costs . . . no oil replacements, no removal of oil for treating, no downtime for cleaning oil systems that stay entirely clean. Moreover, there is no time limit on these benefits. You will receive with each fill of oil a written guarantee that NONPAREIL Turbine Oil will last as long as your turbine, and that its neutralization number will stay below 0.15 mg. KOH/gm.

Have a Standard Oil lubrication specialist show you service records that, in each case, cover 21 years of continuous operation on NONPAREIL Turbine Oil. Ask him for case histories that show how NONPAREIL has reduced utility lubrication costs as much as 68%. You can reach a lubrication specialist through your local Standard Oil Company (Indiana) office. Or, if you wish, write:

Standard Oil Company (Indiana), 910 South Michigan Ave., Chicago 80, Illinois.

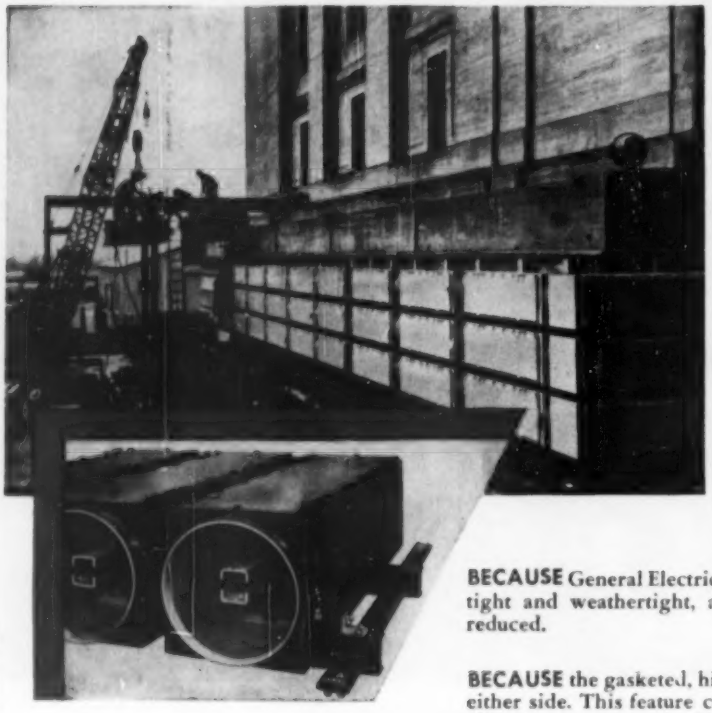
NONPAREIL
TRADE MARK
Turbine Oil

STANDARD OIL COMPANY (INDIANA) STANDARD

11 of the 16 largest turbine-generators*

use

GENERAL ELECTRIC ISOLATED PHASE BUS RUNS



RATINGS
15 and 23 kv
1200 to 7000 amperes

Your G-E Sales Representative has complete information about isolated-phase bus runs. Ask him for a copy of GEA-5460, a 28-page publication that will aid you in planning your bus runs, or write to *Apparatus Department, General Electric Company, Schenectady 5, New York.*

BECAUSE General Electric isolated-phase bus runs are dust-tight and weathertight, and maintenance costs are thus reduced.

BECAUSE the gasketed, hinged covers can be opened from either side. This feature cuts inspection time and costs by allowing access to the interior of the run from the most convenient position. Cover lugs release the cover without removal of bolts. The cover is swung open on either one of two sets of hinges.

BECAUSE you receive G-E isolated-phase bus runs completely assembled as a three-phase package, including running ground bus. They are installed in a short time at lower predictable costs.

BECAUSE you have one source of responsibility when you order from General Electric—complete co-ordination between planning, engineering, manufacturing, and service facilities to give maximum savings efficiency to the customer.

*Installed and planned, rated 6000 amperes and over.

GENERAL ELECTRIC

If you need a control mechanism which can **combine** control signals

Send for this bulletin

In all except the very simplest control systems, there is need for control mechanisms which can combine control signals. Some of these combinations involve addition or subtraction of control signals, while others involve multiplication, division, or even more complicated functions. The Hagan Ratio Totalizer was designed for almost universal application in this type of service. It represents an advance in simplicity and versatility over all devices of this class which have been available previously.

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RING BALANCE FLOW AND PRESSURE INSTRUMENTS
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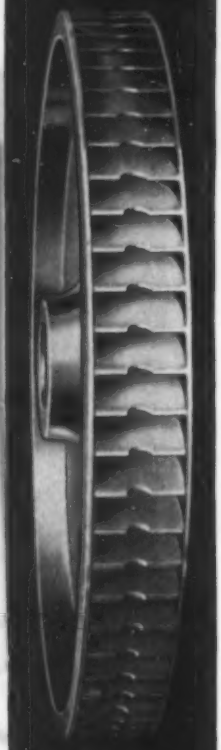
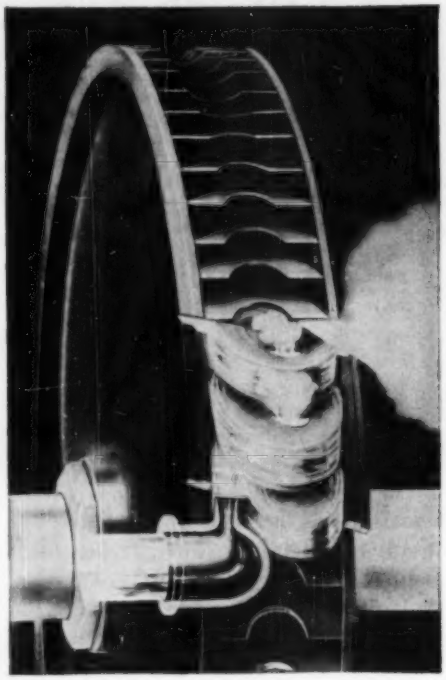
TERRY





Action of steam in Terry wheel turbine. The steam issues from an expanding nozzle at high velocity and enters the side of the wheel bucket in which its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is caught in a stationary reversing chamber and returned again to the wheel. This process is repeated several times until practically all of the useful energy has been utilized.

NO PARTS TO LOOSEN OR WORK OUT

The rotor of the Terry Wheel Turbine is a single forging of special composition steel, in which a series of semi-circular buckets is milled. There are no separate parts to become loose or work out.

The power-producing action of the steam takes place on the solid curved backs of these buckets or pockets. Therefore close clearance is unnecessary and wear on the blades forming the pockets is of little consequence, as it does not materially affect horsepower or efficiency.

For detailed information about this effective construction and its advantages, write us on your business letterhead for a copy of Terry Turbine Bulletin S-116.

T-1172

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

Get All-Around Motor Protection with

SAFETY-CIRCLE

THAT SOLID CAST IRON FRAME protects *Safety-Circle* working parts against physical damage from every angle. The completely enclosed bottom provides extra protection and extra strength. End brackets are drip-proof at no premium.

Because the frame is cast iron, it is resistant to rust and corrosion. It withstands physical abuse and will not distort.

Protected Inside, Too

Safety-Circle protects against internal breakdown with multiple-dipped and baked stator and die-cast aluminum rotor. *Ball bearings are factory-lubricated and need no attention for years.* Wide open internal construction and large fans keep temperatures well within rated limits.

Don't be satisfied with a motor that gives you less than full protection. Insist on the extra protection of *Safety-Circle.*

For complete details on *Safety-Circle* advantages, see your A-C Authorized Dealer, Sales Office, or write for Bulletin 51B6210B. Sizes from 1 to 20 hp, 326 frames and smaller.

A-3145

Safety-Circle, Texrope and Vari-Pitch are Allis-Chalmers trademarks.

ALLIS-CHALMERS, 953A SO. 70 ST.
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by Allis-Chalmers Authorized Dealers, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

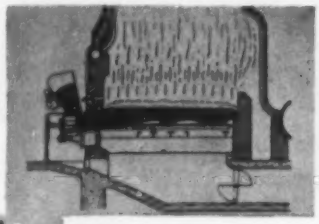
TEXROPE — Belts in all sizes and sections, standard and Vari-Pitch sheaves, speed changers.

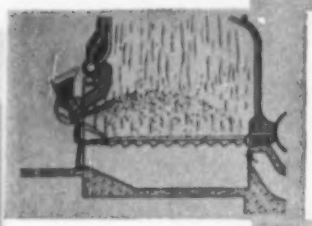
PUMPS — Integral motor and coupled types from ½ in. to 72 in. discharge and up.

For every fuel market and every type of load there is *one best* method of firing. The selection of that *one best* method for the fuel and load conditions of a particular plant calls for judgment based on broad experience and free from any incentive to favor one type of fuel burning equipment over another.

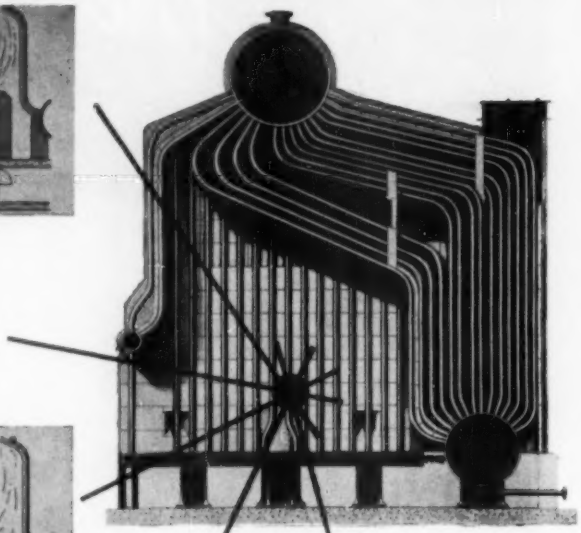
The Type VU-10 Boiler is designed for five fully standardized methods of firing—spreader stoker, single-retort underfeed stoker, chain grate stoker, oil or gas burners. The furnace design is such that any of these methods may be substituted for any other should a change in the fuel market make it advantageous.

TYPE E UNDERFEED STOKER

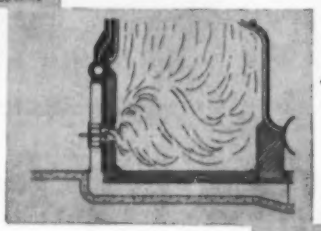




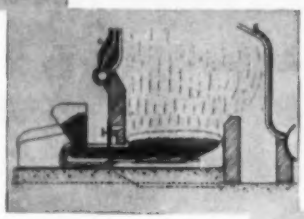
SPREADER STOKER



OIL OR GAS BURNERS



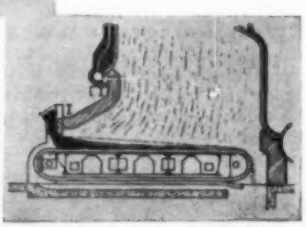
SKELLY UNDERFEED STOKER



C-E Vertical-Unit Boiler

TYPE VU-10

CHAIN GRATE STOKER



COMBUSTION ENGINEERING

ALL TYPES OF BOILERS, FURNACES, PULVERIZED FUEL SYSTEMS AND STOKERS; ALSO SUPERHEATERS, ECONOMIZERS AND AIR HEATERS

Why buy a Boiler Unit piecemeal?

A piecemeal boiler unit is one in which some of the major components are purchased from different manufacturers.

There is no assurance . . . certainly no protecting guarantee . . . that the resulting assembled compromise will meet your performance requirements. If you buy piecemeal, you must accept the uncertainties inherent in divided responsibilities for overall results.

That is why it will pay you to investigate the Vertical-Unit Boiler, Type VU-10. Here is a completely integrated unit . . . boiler, water-cooled furnace, setting and fuel burning equipment . . . available from one manufacturer — Combustion Engineering—Superheater—a recognized leader in both the fields of fuel burning and steam generation. From the initial design stage, the relationship of each of the components, one to the other, has been so developed as to provide the highest possible degree of correlation and standardization. And . . . of prime importance to the buyer . . . the overall performance is underwritten by the C-E sales policy of "one contract, one guarantee, one responsibility."

So—buy *your* next boiler as a *complete* unit . . . the VU-10. Enjoy the peace of mind that comes from the knowledge that you have an installation for which one manufacturer—Combustion Engineering—Superheater — is responsible for fulfillment of performance guarantees. Moreover, you will be able to count upon a reliable source for whatever service or spare parts you may require during the many years that represent the useful life of a modern steam generating unit. B-440

— SUPERHEATER, INC.

200 MADISON AVENUE, NEW YORK 16, N. Y.

Pointers on Pumps

WHAT HAPPENS WHEN THE SPEED OF A CENTRIFUGAL PUMP IS CHANGED?

The characteristics of a centrifugal pump are revealed by curves showing the relation between developed head and capacity, and between brake horsepower and capacity. These curves are usually based on a constant speed and a definite impeller diameter. When the pump's speed is changed, the resulting changes in its performance curves can be predicted by a few calculations. For every point on the original curves there is a corresponding point on the curves for the new speed — and by plotting a sufficient number of these points, curves can be drawn to show the pump performance at the new speed.

HOW TO PLOT THE PERFORMANCE CURVES FOR A 4" PUMP AT 1600 RPM WHEN THE CHARACTERISTICS AT 1750 RPM ARE KNOWN

GPM = gallons per minute RPM = revolutions per minute
H = head in feet BHP = brake horsepower
At constant impeller diameter:

$$\frac{GPM_2}{GPM_1} = \frac{RPM_2}{RPM_1} = \frac{\sqrt{H_2}}{\sqrt{H_1}} = \frac{\sqrt[3]{BHP_2}}{\sqrt[3]{BHP_1}}$$

Taking 900 gpm and 80 ft. head at 1750 rpm as point number 1, then:

$$GPM_2 = \left(\frac{RPM_2}{RPM_1}\right) GPM_1 = \left(\frac{1600}{1750}\right) 900 = 823 \text{ GPM}$$

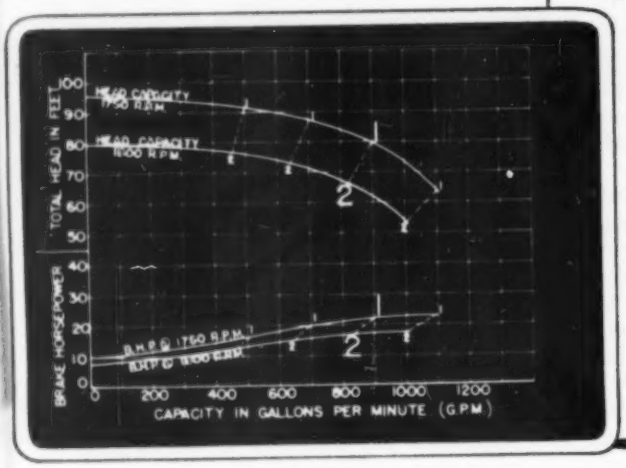
$$H_2 = \left(\frac{RPM_2}{RPM_1}\right)^2 H_1 = \left(\frac{1600}{1750}\right)^2 80 = 66.8 \text{ Feet}$$

$$BHP_2 = \left(\frac{RPM_2}{RPM_1}\right)^3 BHP_1 = \left(\frac{1600}{1750}\right)^3 22 = 16.8 \text{ BHP}$$

By taking other points for number 1, such as 500 gpm at 91 feet, 700 gpm at 87 feet and 1100 gpm at 64 feet, enough corresponding number 2 points are located to draw the expected 1600 rpm performance curve.

NOTE: It is also possible to predict the effect of changing the impeller diameter at a constant speed, by applying the basic formula:

$$\frac{GPM_2}{GPM_1} = \frac{\text{Diameter}_2}{\text{Diameter}_1} = \frac{\sqrt{H_2}}{\sqrt{H_1}} = \frac{\sqrt[3]{BHP_2}}{\sqrt[3]{BHP_1}}$$


TOTAL HEAD IN FEET
HEAD CAPACITY 1750 R.P.M.
HEAD CAPACITY 1600 R.P.M.
BRAKE HORSEPOWER
B.H.P. @ 1750 R.P.M.
B.H.P. @ 1600 R.P.M.
CAPACITY IN GALLONS PER MINUTE (G.P.M.)

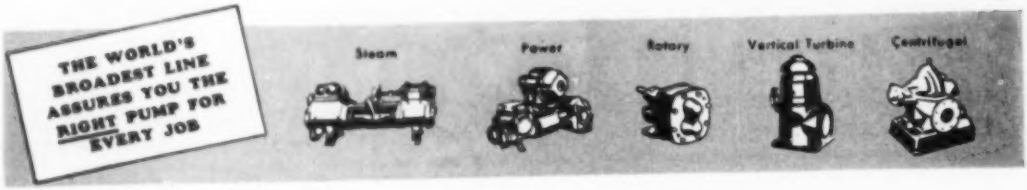
For Expert Advice . . .

on any pumping problem, contact our nearest District Office. And for sure satisfaction in any pumping application, choose from the most complete line of pumps in the field . . . the line that proves *there's more worth in Worthington. Worthington Pump and Machinery Corporation, Centrifugal Pump Division, Harrison, N. J.*

WORTHINGTON

C-D-1

THE WORLD'S BROADEST LINE ASSURES YOU THE RIGHT PUMP FOR EVERY JOB



Hall Laboratories is set up to do all manner of things, but with just one objective—to aid industrial plants in the solution of every problem relating to the procurement, treatment, use and disposal of *water*.

The bulletins listed on this page are designed to help you determine the nature of your water problems, show you what you can do about them, and explain how Hall Laboratories can contribute toward their solution.

We will be glad to send you any or all of these bulletins. Just check the ones you want, and mail coupon to Hall Laboratories, Inc., Hagan Building, Pittsburgh 30, Pa.

☐ 1. Water Problems Neither Begin Nor End at the Boiler
Reprints of a series of advertisements tracing the course of water through an industrial plant and showing the problems which may arise at each stage

☐ 2. Your Most Important Raw Material
Showing the importance of water in modern industry and explaining the functions of Hall Laboratories

☐ 3. Let's Consider Your *Whole* Water Problem
Discusses the inter-relation of industrial water problems, from procurement to re-use or disposal, with specific case histories from several plants.

☐ 4. One-Minute Water Hardness Tests
Procedures and reagents for the new Schwarzenbach tests as adapted for field use by Hall Laboratories. Total Hardness, Calcium and Magnesium

☐ 5. Conductometric Determination of Solids
Use of Conductivity Meters for determining solids in boiler water or steam

Calgon®, sodium phosphate glass, developed by Hall Laboratories, is a powerful and versatile tool in solving many water problems. The following pamphlets describing important applications of Calgon are also available.

☐ 6. Calgon Restores Capacity of Wells—
Describing a new, effective and safe method of well cleaning which, in a number of cases, has made additional well fields unnecessary

☐ 7. Calgon Controls Corrosion—
Threshold Treatment of water supply systems and other industrial applications

☐ 8. Calgon Stabilizes Dissolved Iron and Manganese—
Prevention of "Red Water" and "Black Water"

☐ 9. Calgon Prevents Lime Scale—
With special reference to scale problems in industrial plants

HALL *plant-wide* WATER SERVICE

BOILER WATER CONDITIONING

PROCUREMENT, TREATMENT, USAGE AND DISPOSAL OF INDUSTRIAL WATER

HALL LABORATORIES, INC.
Hagan Building
Pittsburgh 30, Pa.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐

Name.....

Position.....

Company.....

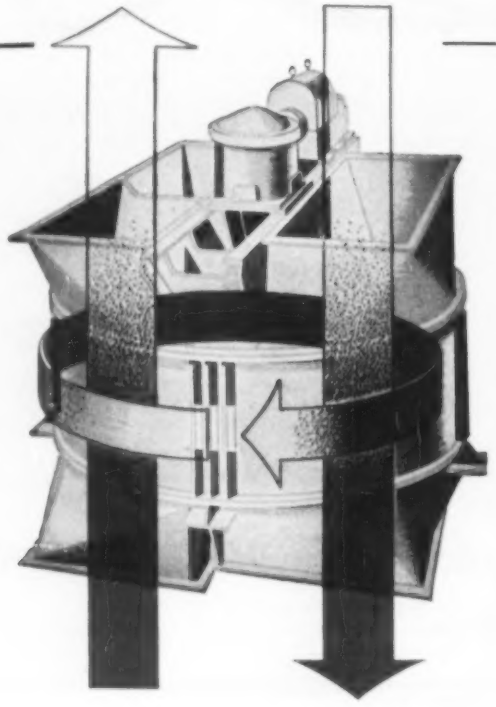
Number & Street.....

City..... Postal Zone..... State.....

PE-12

Increase the efficiency of your present boiler

with the *Ljungstrom* AIR PREHEATER



The installation of a Ljungstrom air preheater on your present boiler offers the opportunity for considerable fuel savings that will more than offset the initial cost of the preheater in a matter of a few years.

The regenerative counterflow principle of the Ljungstrom permits operation at lower exit gas temperatures . . . assuring increased heat recovery and reducing the amount of fuel required. Moreover, the compactness and lightness of the preheater makes it possible to install it on your present boiler with minimum change in the existing structure.

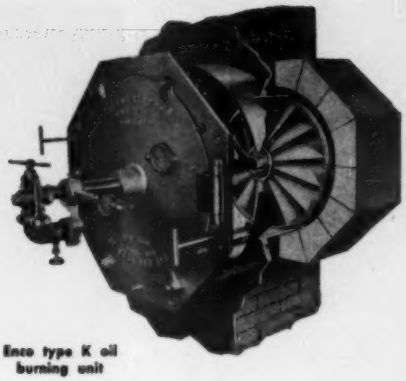
For more information as to how you can approach modern performance standards with a boiler that is operating without an air preheater, or with out-of-date air preheater, write to the Air Preheater Corporation. Our engineers will welcome the opportunity to show you how the Ljungstrom can raise the over-all efficiency of your plant.

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves the heat is transferred from the waste gases to the incoming cold air.

THE AIR PREHEATER CORPORATION

60 EAST 42nd ST. · NEW YORK 17, NEW YORK

ENCO
OIL and GAS
BURNER UNITS



Enco type K oil burning unit

High load or low, you can count on completely uniform combustion and greater fuel economy with the Enco Type K Oil and Gas Burner Unit. It is flexible three ways . . . (1) designed for use with either oil or gas—or both, (2) flexible where steam demands swing sharply and (3) can be operated by either natural or forced draft.

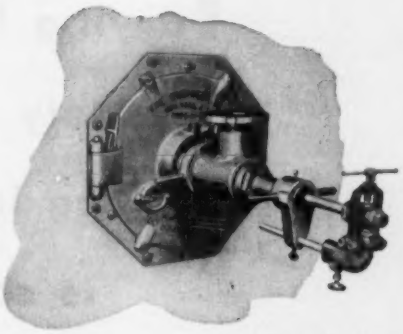
ENCO BURNER UNITS ARE MADE in many sizes to suit all capacity requirements.

Enco Interchangeable Atomizers

Wide Range Mechanical—Capacity range of 10 to 1. Manual or automatic control. Constant high oil pressure at atomizer insures efficient atomization over entire load range without recirculating or returning oil.

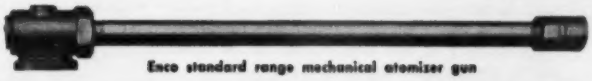
Steam or Air—Capacity range of 10 to 1. Controlled by manual or automatic pressure regulation.

Standard Range Mechanical—Available in all sizes to suit load and capacity requirements.

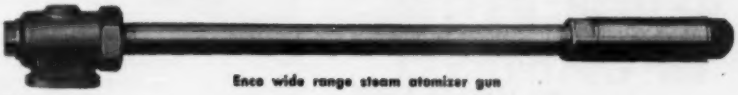


Enco type K gas-oil burning unit

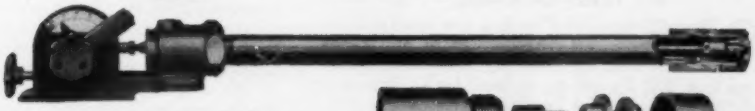
BULLETINS ON REQUEST
WRITE TODAY



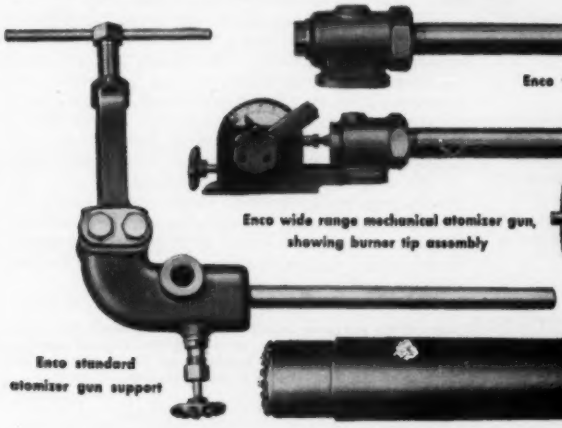
Enco standard range mechanical atomizer gun



Enco wide range steam atomizer gun



Enco wide range mechanical atomizer gun, showing burner tip assembly



Enco standard atomizer gun support

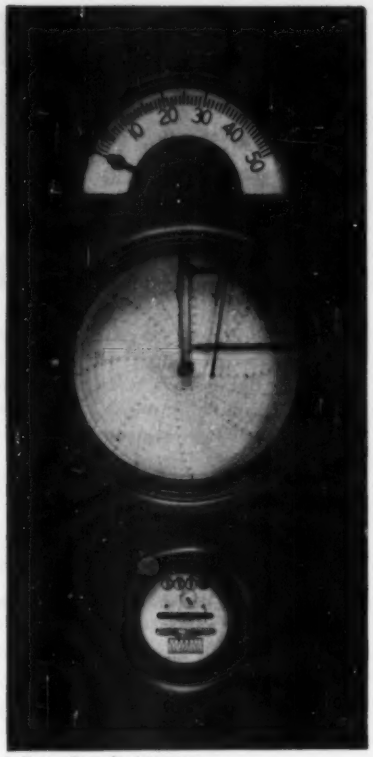
Enco gas burning gun

THE ENGINEER COMPANY 75 WEST STREET, NEW YORK 6, NEW YORK

IN CANADA: F. J. RASKIN, LTD., 4220 IBERVILLE ST., MONTREAL 34 P.Q.

Integrator

Varying flows are accurately totalized because the integrator is continuous



Indicator-Recorder-Integrator

The Republic flow integrator, being of the modified watt-hour type, totalizes continuously—not intermittently. It operates independently of the recorder and its accuracy is not dependent on or affected by any clock mechanism or mechanical action.

The Republic meter is, on this account, peculiarly fitted to follow all changes in flow rate and accurately measure highly fluctuating flows.

ALL TYPES OF FLUIDS

Republic electric type flow meters are available for measuring the flow of all types of liquids and gases. Meter bodies are built for metering fluids at line pressures up to 5,000 lb. per sq. in. and for all ranges of differential pressure. The reading instruments—indicator, recorder and integrator—are of the remote reading type and can be located any distance from the point of flow measurement.

ANY COMBINATION

While each Republic reading instrument is standard in design and construction each is especially calibrated for the particular flow measurement for which it is specified. Any reading instrument, indicator, recorder or integrator, may be obtained separately or in any combination desired, making possible the highest degree of flexibility in plant use.

SIMPLE IN OPERATION

The Republic electric meter is the only flow meter commercially manufactured which is strictly electric in its operation. All other types of so called electric meters use the motion of the mercury to move a float or produce a force which is then converted into an electrical value which is in turn transmitted to a receiving or reading instrument. In the Republic meter, the transmitted electrical value is determined directly by the mercury motion, thus eliminating one of the steps in the sequence, and simplifying the mechanism to that extent. There are no floats, levers, cams, rotating shafts or anything else to interfere with the unimpeded movement of the mercury, which has no work to perform, but merely fulfills the function of making contact.

NEW DATA BOOK

Just off the press—a completely new data book describing and illustrating, in detail, the operating features of the Republic Flow Meter and its many applications. Write for your copy of Data Book No. 702—there is no obligation.

REPUBLIC FLOW METERS CO. ● 2240 DIVERSEY PARKWAY • CHICAGO 47, ILLINOIS

ALABAMA POWER CO. (*Gorgas)
APPALACHIAN ELECTRIC POWER CO. (*Philip Sporn)
OHIO POWER CO. (*Philip Sporn)
CONSOLIDATED EDISON CO. (Astoria)
ILLINOIS POWER CO. (Hennepin)
CAROLINA POWER & LIGHT CO. (*Lumberton)

In 1950

as in 1949-'48-'47-'46 etc., etc.

DIAMOND
SOOT BLOWER LEADERSHIP
Continues

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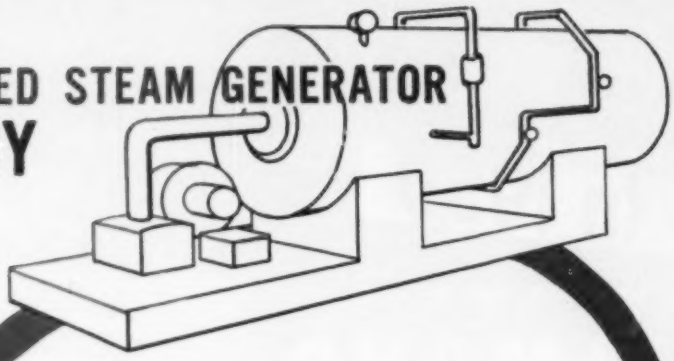
CENTRAL HUDSON GAS & ELECTRIC CO. (Danskammer)
CONSOLIDATED GAS, ELECTRIC LIGHT & POWER CO. (*Gould Street)
CINCINNATI GAS & ELECTRIC CO. (Clermont)
CENTRAL ILLINOIS PUBLIC SERVICE CO. (*Hutsonville)
INDIANA & MICHIGAN ELECTRIC CO. (Tanners Creek)
GEORGIA POWER CO. (*Plant Yates)
INDIANAPOLIS POWER & LIGHT CO. (*White River)
CENTRAL MAINE POWER CO. (Mason)
NIAGARA MOHAWK POWER CORP. (*Oswego)
IOWA POWER & LIGHT CO. (*Des Moines)
PUBLIC SERVICE ELECTRIC & GAS CO. (*Sewaren)
PUBLIC SERVICE CO. OF COLORADO (*Arapahoe)
PUBLIC SERVICE CO. OF INDIANA (*Edwardsport)
LOUISVILLE GAS & ELECTRIC CO. (*Paddy's Run)

JERSEY CENTRAL POWER & LIGHT CO. (*South Amboy)
CONSUMERS PUBLIC POWER DIST. (Bluffs)
NORTHERN STATES POWER CO. (*Sioux Falls)
KANSAS POWER & LIGHT CO. (*Lawrence)
KANSAS POWER & LIGHT CO. (*Tecumseh)
POTOMAC ELECTRIC POWER CO. (*Benning)
TENNESSEE VALLEY AUTHORITY (New Johnsonville)
SAN DIEGO GAS & ELECTRIC CO. (*Silver Gate)
SOUTHERN COLORADO POWER CO. (Rocky Ford)
TENNESSEE VALLEY AUTHORITY (Bridgeport)
CAROLINA POWER & LIGHT CO. (*Goldsboro)
UNION ELECTRIC CO. OF MISSOURI (Meramec)
VIRGINIA ELECTRIC & POWER CO. (*Possum Point)
WESTERN MASSACHUSETTS ELECTRIC CO. (*West Springfield)
OHIO EDISON CO. (*Burger)
GEORGIA POWER CO. (Brunswick)
MAINE PUBLIC SERVICE CO. (Caribou)

BETTER BOILER CLEANING AT LOWER COST
Is the Reason

Ideal Combination

FOR TOP SELF-CONTAINED STEAM GENERATOR EFFICIENCY



1

Nalco WATER TREATMENT

SCALE AND CORROSION PREVENTION

With a Nalco Service Policy and Nalco Chemicals to fit your water treatment requirements, you can keep your self-contained boilers operating indefinitely at top efficiency — without any of the costly difficulties caused by scale and corrosion. This part of the Nalco System was designed expressly to provide small boiler users with the same complete water treatment services enjoyed by thousands of the country's largest power plants. A new 4-page bulletin gives complete details on The Nalco System as applied to the modern self-contained boiler. Your copy will be sent promptly, without obligation.

Write for Bulletin 49

2

Nalco SR-155 FUEL OIL ADDITIVE

FUEL SAVING . . . CLEAN BURNERS

Nalco SR-155 is a *complete* fuel oil additive. It replaces two, three or more single-purpose additives to: (1) keep storage tanks, fuel lines and burners free of sludge and gum; (2) prevent soot formation in the firebox and flues; (3) inhibit corrosion throughout the fuel system; and (4) act as a combustion catalyst to assure complete burning of oil. Fuel savings and reduced maintenance costs usually more than repay the cost of continuous SR-155 treatment — and very little SR-155 is needed per 1,000 gallons of fuel oil! Details on Nalco SR-155 will be sent on request.

Write for Bulletin 46

NATIONAL ALUMINATE CORPORATION

6224 West 66th Place • Chicago 38, Illinois

Canadian inquiries should be addressed to Alchem Limited, Burlington, Ontario

THE *Nalco* SYSTEM • Serving Industry through Practical Applied Science

HELPFUL BULLETINS

Answers to many operating and maintenance problems will be found in these new bulletins and catalogs. List paragraph numbers of those you want on coupon below, detach and mail

INSTRUMENTS AND CONTROLS

101 **Putting the Ratio Totalizer to Work**—Twelve suggested applications of company's ratio totalizer in automatic control circuits are described and illustrated by diagram in 8-pp Bulletin 5466. This new device is a pneumatically operated control mechanism for combining input control pressures and spring forces to produce a single output control pressure. Applications in computing circuits include addition, subtraction, multiplication and division, averaging and reversal of loading pressure, also specialized applications. A cutaway drawing in color shows principles of operation. Hagan Corp.

102 **Regulator Data**—Form 1003, 4 pp, gives useful information on temperature regulators, pressure regulators, and desuperheaters. A complete explanation of the principles of pilot-operated regulating valves is included in addition to data and illustrations of 27 pilots. Spence Engineering Co., Inc.

103 **Thermocouple Manual**—This is a new 42-pp edition of company's data book and catalog containing current prices, application recommendations on instrument sensing units and accessories. Among special items listed are resistance bulbs and wells, radiation detector and a new molten metal thermocouple for ferrous metals. Standard thermocouples, protecting tubes, lead wire and insulators are covered. Book also includes data on checking, selecting and ordering thermocouples, wire sizes and resistance and temperature-mv curves, helpful in applying indicating, controlling and recording instruments. Wheelco Instruments Co.

104 **Water Temperature Control**—How to regulate the cooling water system of diesel and gasoline engines and air compressors with company's water temperature control is explained and illustrated in this 4-pp bulletin. Two types of regulators and dial indicating thermometers are pictured and three typical applications diagrammed. Photos show some installations. The Powers Regulator Co.

PACKINGS

105 **Buyers' Guide on Packings**—Twenty-pp Catalog PC-101 brings together all material on company's Palmetto packings previously available only in product bulletin sheets, and includes data on a new packing for liquid pistons on inside-packed piston pumps. Self-lubricating, molded and special packings are covered in detailed text and there's a full explanation of performance of the self-lubricating type. Photos, application charts are provided, also complete ordering information. Greene, Tweed & Co.

106 **Teflon Packings**—Form AD143 offers 8 pp of product information on packings and gasketing material made of Teflon, giving their properties, typical and special applications. Available styles and types are pictured, their construction described and sizes given. Includes chapter on the toxicology of Teflon at extremely high temperatures and precautions to be observed. The Garlock Packing Co.

107 **Long Wearing Piston Packing**—Form 4562, 8 pp, stresses use of company's composition cups for packing the pistons of air and hydraulic cylinders and reciprocating pumps. Engineering information included covers properties, textures available, temperature and pressure data, and sizes. Many types of machines on which these cups are used are pictured. Darling Valve & Mfg. Co.

ELECTRICAL

108 **Power Centers**—Bulletin B4163, 36 pp, although presenting standardized power centers utilizing both dry-type and liquid-insulated transformers, features the more modern dry type, stressing their economy, safety advantages and ease of installation. Also covers standardized switchgear incorporated in all power centers. Provides data showing how these centers serve simple and loop primary radial systems, banked secondary radial systems, primary and secondary selective radial systems, primary selective network and spot network systems. Also describes centers with high voltage switchgear, outdoor power centers and self-contained power centers. Westinghouse Electric Corp.

109 **Motor Starters**—Twelve-pp Bulletin 14B6410A describes and illustrates motor starters for 2300 to 5000-v squirrel cage, wound rotor, synchronous and multi-speed motors. Covers advantages of control cabinet, air and oil-immersed contactors available, protection afforded by these starters, construction details and dimensions. Allis-Chalmers Mfg. Co.

110 **Indicating Fuse Cutouts**—Bulletin GEC-704, 8 pp, introduces a new line of heavy-duty fuse cutouts of the enclosed indicating type. Describes and illustrates design and operating features of 100-amp and 200-amp cutouts as well as a 400-amp disconnect cutout. Includes dimensional and rating data on the 100-amp cutout which is priced the same as the 30-amp unit which it replaces. General Electric Co.

111 **Disconnecting Switches**—A complete line of indoor air-disconnecting switches is described in 8 pp booklet B-4728. Gives highlights on their design and operation, as well as applications. Switches listed include five outdoor and two indoor types. Hookstick operated switches, for use when single-phase operation is permissible, are covered. Other types described are for gang operation, with or without arcing horns, for interrupting small magnetising and charging currents and for no-load applications. Rotating and tilting insulator types are also described. Westinghouse Electric Corp.

112 **Controls and Resistors**—Catalog 50 is a 20-pp buyers' guide covering company's broad line of control equipment, resistors and resisting devices. It is fully illustrated and provides all necessary ordering information, including list prices. Clarostat Mfg. Co., Inc.

Use this CARD for information on ADS and NEW PRODUCTS also

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Also, use this card for more information on advertised products.

113 For Practical Distribution Service—A single-circuit unit substation arranged for maximum accessibility and easy maintenance is described in 8-pp Bulletin 11287407. Photos show how transformer, regulator and switchgear are contained in a single weatherproof enclosure. Flexibility and other advantages are discussed. Also described is an optional feature, a built-in circuit breaker by-pass switch. Allis-Chalmers Mfg. Co.

114 Synchronous Motor Starters—Bookl let B-4279, 8 pp, describing synchronous motor control, for the operation and protection of all types of synchronous motor drives, features photos keyed to line drawings explaining how the starters work and pointing out their features. Company's new Type ASR polarized slip-frequency field application relay is pictured and its operation described. This relay can be adjusted on the job. Booklet also introduces a pull-out relay to protect the motor in case it fails to synchronize or pulls out of synchronization after being in step. Westinghouse Electric Corp.

PIPING, VALVES, TRAPS

115 Pulsation-Free Compressor Piping—Illustrated Bulletin PDS-8501, 4 pp, describes company's pulsation dampening piping system designed for pulse-free performance. Tells how this piping is comparable in first cost to other piping, but affords higher operating efficiency, improved flow measurement and lower maintenance costs. Explains pulsation phenomena in gas compression systems and how pulsation dampening principle is applied. The Fluor Corp., Ltd.

116 Hydraulic Motor Valve—Principle of operation and construction details on a motor valve for open-and-shut control which features powerful hydraulic action and economical operation are explained and illustrated in Bulletin 1000-A, 4 pp. Dimensions and capacities for both single-seated and double-seated types included. Barco Co., Inc.

117 Pressure Reducing Valves—Selection and engineering data on pressure reducing valves, including those for remote control of reduced steam or water pressures, are presented in 12-pp Bulletin 477-A. Valve types are illustrated photo and sectional views. Also described and illustrated is company's desuperheater. Northern Equipment Co.

118 Small Valves for Rugged Service—Midget-size, two- and three-way packless solenoid valves designed for severe and frequent operating service are described in a folder comprising Bulletins 6262 and 6314. Available with brass or stainless steel bodies, these valves are for air, gas, water, light oil, refrigerants, for temperatures to 212 F. Full ordering information, including dimensions, prices and flow data, is given. Automatic Switch Co.

119 Float and Lever Valve Chart—By reference to intended service, maximum pressure drop between inlet and outlet, maximum temperature and other factors, this handy selection chart makes it easy to choose the correct valve. Also helps determine proper size and indicates valves suitable for deadend service. Both this chart and Bulletin 349 on float valves are available. Klipfel Valves, Inc.

120 Hydraulic Valve Catalog—Practically all types of four-way hydraulic valves — 90 models in all — are illustrated and described in 52-pp Catalog Section 302. Listings include working drawings, specifications, cutaway views and operational diagrams of piston designs. Circuit layouts for important types of control show arrangement of all necessary hydraulic equipment and are accompanied by description of circuit operation. Catalog features company's simplified design with balanced type piston, O-rings for sealing stem and cover and large passages for unrestricted flow. Rivett Lathe & Grinder, Inc.

121 Improved Steam Traps—Illustrated Bulletin 500, 4 pp, contains specifications, capacities, sizes, pressures, weights and list prices of principle types of company's super steam traps which feature simplified piping arrangements, easier accessibility, reverse flow and other advantages. Data is also provided on self-cleaning strainers and forged steel steam traps for higher pressures and super heated steam services. The V. D. Anderson Co.

PAINTS, COATINGS

122 How to Choose and Use Paint—The proper selection of paint and paint products — and the way to apply them — are covered in this 13-pp handbook. Describes products for use in industrial maintenance, public utilities, electrical manufacturing, steel fabrication applications. Contains information on applying primers and finishes to transformers, circuit breakers, transmission towers and structural steel. Spreading rate and drying times are given. Preservatives are recommended for wooden structures and fabrics such as awnings and fire hose. Waterproofing and concrete sealing coatings are also discussed. James B. Sipe and Co.

123 Brush-on Coating—Data Sheet C-50, 2 pp, tells the advantages, limitations, corrosion resistance, uses, applications and cost of a modification of phenol formaldehyde resins that require no baking to obtain maximum hardness and corrosion resistance. This coating is suggested for applications where a tile-like surface is desired for sanitary reasons. Carboline Co.

124 Super Refractory Coating—This 4-pp folder describes a ceramic refractory coating with many advantages for use in new refractory construction and as a maintenance coating. Includes test data, application information. Cera-Kote, Inc.

MECHANICAL POWER TRANSMISSION

125 Variable Speed Drive—Bulletin AS-1600-B2 describes company's 1 hp variable speed drive which, at 1725 rpm input offers a range of 215 to 3450 rpm. Discusses compact design permitted by tandem belt and other advantages of this drive; gives ratings and includes dimensional drawings. Worthington Pump and Machinery Corp.

126 Right-Angle Reducer — Engineering Bulletin 3110, 16 pp, illustrates and describes company's new all-steel Motoreducer with adaptable right angle head for horizontal or vertical applications and available with output shaft single or double ended. Design advantages and typical applications are covered; specifications, dimensions and selection tables included. The Falk Corp.

127 Pillow Blocks and Bearing Units—Bulletin 86, 8 pp, provides general descriptions, illustrations and engineering data on pillow blocks and spherical, and cylindrical bearing units and hanger bearings. Gives dimensions, bearing capacities. Also discusses lubrication of the bearings, giving recommended grades of lubricants marketed by several manufacturers. W. A. Jones Foundry & Machine Co.

PUMPS

128 Boiler Feed Pumps—Bulletin 100, 14 pp, illustrated in color, describes in detail centrifugal pumps for boiler feed service. Explains and pictures construction and major parts, explaining in detail the floating seal incorporated. Capacity data is provided, also vapor pressure tables. Pacific Pumps, Inc.

129 Centrifugal Pumps—A new line of multi-stage centrifugal pumps for high pressure applications to 1200 psi and

(Continued on page 120)

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A Power Company asked: "Can you help us stop tube failures?"

Dowell Service provided a fast, effective solution!

A midwestern power and light company, operating 350,000 lb. per hour steam generators, was having numerous unscheduled shutdowns because of tube failures. Although tubes were turbined periodically and inspections showed that deposits were small in amount, tubes continued to blister. A crisis was reached when 11 outages occurred in 18 days!

Dowell Service provided the answer with a *more effective, faster and more economical* method of maintenance cleaning. Tube failures at this power house have been practically eliminated. A regular cleaning schedule using Dowell Service has solved similar problems in many other plants.

What is Dowell Service? Experienced engineers fill the equipment to be cleaned with special liquid solvents designed to dissolve and disintegrate the profit-stealing deposits from all surfaces, even the most complex, *in a few hours.* The solvents are carried to the job in Dowell pump trucks and are pumped into the unit through regular connections. There is no dismantling.

Call Dowell for consultation on your cleaning problems. A Dowell engineer is as near as your telephone. No obligation, of course.

Other recent Dowell jobs:

Anthracite filters cleaned by Dowell Service in one working day. Backwash rate increased from 75 to 385 g.p.m.

★

Five air conditioning compressors cleaned for office building in 8 hours by Dowell Service. Result: $15.70 per day saved on power demand.

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Two 40,000 lb./hr. boilers cleaned for paper company in 24 hours. Result: 37 tons of fuel per day saved under same load conditions.

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R-S valvEvents

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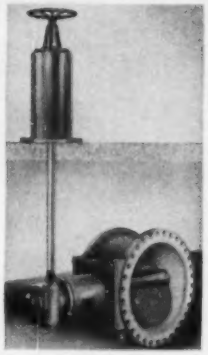
Photograph shows R-S 60-inch Valve discharging sewage from an oil refinery. The valve is operated by means of dual air diaphragm top works and stainless steel linkage, with a handwheel for emergency operation. By means of a level device, the valve is automatically closed at high tide thus eliminating the possibility of flooding the refinery. Valve opens automatically should the air pressure fail. Under emergency conditions or should all power fail, one man can close the valve with a few turns of the handwheel.

R-S Valves are used in air, gas, liquid, steam and semi-solid service in the pressure range from 2 to 2500 psig. They are available in sizes from 2-inches to 72-inches and larger for the simplified control and shut off of volume and pressure.

Consult with your local R-S Valve Engineers or write direct.

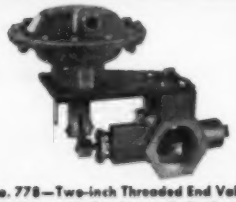
R-S PRODUCTS CORPORATION
4600 Germantown Avenue
Philadelphia 44, Pa.

No. 790—Eight-inch Steel Straight Through Slide Valve with pull lever control. Flange on left side when removed permits replacement of slide or cleaning of valve.



No. 788—Fifty-pound Heavy Duty Service Valve with rubber seat. Equipped with totally enclosed gear reduction drive, extended shaft and floor stand.

No. 769—Steel Off-center Relief Valve for low pressure drop. Hand lever can be used as an instrument lever. Counter weight on right side of valve. Relieves at 1 psi differential pressure.

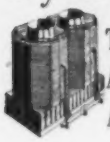


No. 778—Two-inch Threaded End Valve complete with bracket and diaphragm top.

OVER **250**
TOWER COMBINATIONS

FROM **258**
PREFABRICATED
PARTS

why Fluor can give you



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AT THE RIGHT TIME...
AT LESS ERECTION COST

Whatever your cooling problem—process, gas or liquid—Fluor has the cell size and height to meet flexibility and operating requirements. From only 258 standard interchangeable prefabricated parts, over 250 *different* tower sizes and arrangements are possible—the result of over 30 years' experience in the design and manufacture of cooling towers to solve virtually every cooling problem in industries utilizing water as a cooling medium.

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THE RIGHT TOWER *guaranteed* to meet your specified requirements. The octagonal shape, true counter-flow design and "Spirodome" upspray distribution system of a Fluor Counterflo Cooling Tower offer greater cooling capacity per square foot of ground area than any other type tower available!

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AT LESS ERECTION COST because all parts are marked for fast erection. There's no need for trial-and-error or cut-and-fit erection methods. Another saving is realized by the elimination of scaffolding. Extra heavy grid decking supported on 2" x 4" cross bracing—a feature of all Fluor Counterflo Cooling Towers—form the only scaffolding necessary for continuous erection.

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WHAT CAUSES TUBE FAILURE?

When deposits are present, tube failure can usually be readily traced to the insulating effect of deposits on tube metal. The *proper* use of the *proper* water treatment will eliminate this problem.

In many cases, however, deposits are not present in failed tubes. Tube failure frequently results from mechanical action . . . poor circulation, steam blanketing, flame impingement, faulty design and similar troubles. In such cases, the cause of the failure often cannot be readily determined and careful investigation is required.

You can't overcome the problem if you don't know the cause!

The Drew System of Water Treatment eliminates guesswork. It starts with proper diagnosis. It includes recommendations for corrective treatment, and other preventive measures such as modification of operating cycles and redesign of equipment, if required. It is specialized service applied to your individual boiler problem.

Don't gamble with guesses! Consult the Drew Engineer or write for further information.

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NEW EQUIPMENT NEWS

WHAT'S NEW? On these pages the Editors summarize the outstanding industrial developments of leading manufacturers who will supply you, free of charge, the bulletins or other information desired. For ease in making requests use the no-obligation, postage-paid card pages 35-36.

1—MANUAL STARTER

Is equipped with indicating light to show when motor is running

The Motor Sentinel Class 10-023 is suggested for starting and protecting small a-c and d-c motors used with fans, pumps, compressors and other appliances. It is available as a double pole switch with ratings to 1 hp, 250 v.

Quick-make quick-break action is provided by and over-center self-indicating toggle mechanism. Company points out that positive bimetallic overload protection allows safe-capacity overloads, but automatically disconnects the motor on any sustained or damaging overload. This device is housed in a die-cast aluminum NEMA Type 1 enclosure and features straight-through wiring and accessible front terminals. Westinghouse Electric Corp.

2—SEDIMENTATION TANKS

For hot process water softeners, feature radical change in design

As its name indicates, the Sphericone is a hemisphere mounted on top of a cone. The inverted cone provides the uniformly increasing area from tip to circular top, necessary for correct functioning of the tank, while the hemisphere provides increased strength.

The raw water, steam and chemical

inlets, spray heater, deaerator and treated water collector are all mounted in the hemisphere, while the inverted cone contains downtake, sludge bed and rising zone of water being treated. This combination is said to make efficient use of materials and tank space while assuring uniform stress distribution because of the virtual reduction of knuckle radii. Graver Water Conditioning Co.

3—SPACE-SAVING VALVES

For instrument piping and general use feature fewer threaded connections

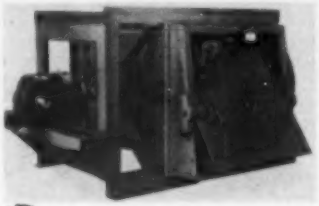
These valves, which combine unions, nipples, reducers, elbows, tees, valve and drain valve into one space saving unit come in nine styles which include those with or without union outlet, as well as offset and jacketed valves.

Features available on all or many of the valves include a safety shut-off, double-seating stem for repacking under pressure, outside screw and yoke when desired, and throttling stem when desired. Jerguson Gage & Valve Co.

4—DRAFT INDUCER

With integral barometric offers more precise control of furnace draft

According to a recent announcement, this company's draft inducers, now equipped with variable speed motors, can be equipped with integral barometic dampers — a combination said to permit highest combustion efficiency. An important feature of the baro-



metric is a hinged explosion gate to relieve excessive pressures that may develop in the breeching. L. J. Wing Mfg. Co.

5—BOILER WATER TREATMENT

Is high-strength compound, formulated to customer specifications

Luminite is a coagulant intended to combine the advantages of chemical and colloidal methods in the removal and prevention of scale formation, for eliminating pitting, congestion, rust, corrosion, foaming and priming in steam boilers. Contending that no two boiler installations are exactly alike, manufacturer of Luminite has this treatment formulated to customer's specifications after a survey of operating conditions. Because of this and Luminite's powerful action it is claimed to provide excellent water treatment at greatly reduced cost per 1000 gal of water evaporated. The Warren Refining and Chemical Co.

6—METAL-CLAD SWITCHGEAR

Is redesigned to conform with recently adopted ASA standards

New design features of this indoor air-magnetic vertical lift switchgear also make it a more versatile unit, according to manufacturer. Maximum design rating on its circuit breaker is 4.76 kva and these breakers are available in interrupting ratings of 50, 150 and 250 mva. Service voltages range between 2300 and 4160 v. More mounting space for instruments has been provided by increasing the height of the panel to 92 in.

Additional new features include a welded-in steel plate floor to provide a smooth rolling surface for the circuit breaker, and guide rails on each side of the breaker compartment. The structural design permits a variety of circuit arrangements and the number of required units may be reduced by utilizing space above main bus and current transformer compartments for mounting auxiliary equipment.

Secondary wiring is routed through enclosed wiring ducts or encased in flexible conduit. Allis-Chalmers Mfg. Co.

7—UTILITY DRILL

For maintenance crews; is light in weight and comes in carrying case

The S17 Utility Drill comes with a complete kit of accessories, including a 14-in. drill steel and three assorted-size rock bits, a star drill adapter and 25 ft of air hose. The drill itself weighs only 19 lb and is described as a self-rotating pneumatic hammer drill. It's handy for placing anchor bolts, for running conduit, cable, pipe. It will drill concrete, brick, or stone with standard drill steel and a star drill adapter included accommodates standard star drills. A special stop-rotation feature converts the S17 to a lightweight chipping hammer. Gardner-Denver Co.

8—SEQUENCE INDICATOR

Shows phase sequence by direction of disc rotation

A polyphase sequence indicator which operates on higher frequencies than usual and a greater cycle span, is the Sellco Phase Rotation Indicator. Its operating range is given at 50 to 600 v, 25 to 400 cycles. At 200 v or greater it will operate up to 2000 cycles.

This indicator is a self-contained, compact instrument weighing less than 3½ lb and measuring 5½ by 6 by 3 in., with a 1¾ by 3 in. window. It requires only one connection of conductors to the polyphase line, and without changing leads or moving switches a quick indication of phase sequence is shown. Housed in a metal case, the unit is described as dust-tight and well insulated electrically. H. H. Sell Electric Co.

9—TORQUE-ARM REDUCER

Is single-reduction unit for output speeds of 115 to 330 rpm

Ease and economy of installing this new reducer is attributed to its shaft mounting. This, says manufacturer, eliminates special engineering, the cost of a foundation, flexible couplings, alid-

piping maintenance costs more now!

You do less of it

by using Dependable Quality

CRANE VALVES

That's why more Crane Valves are used than any other make

. . . no bonnet trouble with this valve

A typical example of low-maintenance Crane Quality—No. 465½ 125-Pound Iron Body Gates. Rarely does the bonnet joint need attention. Flange construction includes reinforcement to prevent distortion and utilizes more bolts, more closely spaced than is usual in valves of this class. Crane precision-guided seating reduces seat and disc wear. Packing has long life because these valves have a deep stuffing box filled with high grade asbestos ring packing. A ball-type gland equalizes the packing load.

Better performance features like these make Crane the better buy in valves of every type. Ask your Crane Representative for a demonstration.

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ing base, and the job of lining up. The compact unit is locked to the driven shaft by two steel collars, one on each side of the reducer. It is anchored to the floor, or any fixed object, by the torque arm.

Available in four sizes covering capacities to 27 hp, this reducer can be driven through any V-belt drive, although its designers recommend use of company's stock sheaves. Flat-belt drive can also be used. Belt tension is adjusted by a turnbuckle in the torque arm. Transferring unit from one machine to another is simplified by use of interchangeable shaft-keyed bushings. Dodge Mfg. Corp.

10—ELECTRONIC INSTRUMENTS

For measurement of any variable measurable in terms of impedance

The Series 500 Strip-Chart Dynamaster is a high-speed, self-balancing a-c bridge for measuring temperature, resistance, conductivity, strain, position, inductance, pressure, force. It can also be used for electric power totalization and as the receiver for company's Metameter System of telemetering.

The measured variable is recorded on a chart 11¼ in. wide and indicated on a large scale. In addition to the single record model, instruments are available for as many as 16 different records on the same chart. Models are offered for full-scale pen travel in 7, 3, and 2/3 sec, with chart speeds from 1 in. per hour to 120 in. per minute. Instruments are housed in case suitable for wall, flush-panel or front-of-panel mounting. The Bristol Co.

11—CENTRIFUGAL PUMPS

Multi-stage type for applications to 1200 psi, capacities to 1600 gpm

The Class HMTA Pumps are built in 3-, 4-, 5, and 6-in. sizes with from three to nine stages. They're described as highly efficient, easily maintained and dependable. Applications cover a wide range of boiler-feed, pipeline pumping, general high-pressure services.

Among new design features incorporated are a cylindrical bore, horizontally-split casing, and compact, unit-type rotor assembly which is easily removed from and installed in the smooth-bore casing. The pressure differential between successive stages in this pump is sealed by corrosion-resistant cast-iron or alloy steel piston rings around the outer diameter of the channel rings. Ingersoll-Rand Co.

12—PILOT BURNER

Has removable filter screen to aid in eliminating lint plugging

Smaller than company's earlier models, the 260 Series Pilot Burner is equipped with a special mounting bracket, designed for various types of appliance installation, which holds both burner and thermocouple in operating relation to each other. General Controls Co.

13—SENSITIZER

Saves time in making low current readings with snap-on volt-ammeter

When plugged in between equipment being checked and the outlet, the Amprobe 10x Sensitizer multiplies the sensitivity of the Amprobe by ten times. For example, a motor drawing 0.7 amp will show 7 amp on the instrument scale. This effectively adds three low-current ranges to company's Amprobe. It is described as particularly valuable when checking small electrical equipment with a snap-on volt-ammeter, especially motors of ¼ hp and under.

Of molded Bakelite, the sensitizer has ten precision windings in one arm. Its capacity is 10 amp for intermittent use, 2.5 amp for continuous use; it costs $3.75. Pyramid Instrument Corp.

14—MIDGET BELT FEEDER

For feeding dry chemicals continuously by weight, has 3 cfm capacity

The Model 50-8 Gravimetric Feeder has an 8-in. belt with 1-ft weigh span. Among features stressed for this new feeder are high accuracy, feeding range of 100 to 1, stainless steel, non-flooding feeding mechanism, infinitely variable speed transmission and automatic alarm. It's equipped with a single ¼ hp motor and one-piece molded sprocket-driven belt. Hopper agitation is proportional to feed rate. Stainless steel cabinet is only 17 by 30 by 17 in. Omega Machine Co.

15—SINGLE TANK DEIONIZER

Removes minerals, silica and CO_2 from water and does it economically

In the past, deionized water has been used for boiler feed in plants operating at moderately high pressure and for processing where the equivalent of distilled water is required. This simplified and more economical form is intended to make deionization possible in extremely high pressure boiler plants and other processes requiring highest quality water.

By using single-tank rather than multiple-tank equipment the investment cost for this new deionizer is lower, company explains, adding that higher quality water is produced more simply, uniform quality water is delivered, less space is needed and less time is needed for regeneration of ion-exchange material, also rinse requirements are reduced.

An important feature of this equipment is a double-check manifold arrangement to guard against loss of zeolite during backwashing and permit use of deeper zeolite beds for increased capacity.

Two types of resinous zeolite exchangers are used — one for cations and one for anions. The former is regenerated by a dilute acid solution, the other by a caustic solution. The two exchangers are intermixed in the single tank, their difference in density permitting them to be divided by backwash into zones for separate regeneration. Elgin Softener Corp.

CATALOG LIBRARY

This monthly list of the latest standard catalogs and bulletins is designed to aid the engineer in maintaining his permanent catalog file of engineering data. The items listed, unlike those under Helpful Bulletins, will appear each month except for additions and deletions determined by space requirements or by the manufacturers issuing the bulletins. Use the Helpful Bulletins coupon in requesting these copies.

WATER TREATING, CORROSION PREVENTION

201 **Water Conditioning Bulletin**—This is an 8-pp discussion of water and the chemicals developed for conditioning it to control scale and algae and inhibit corrosion. Describes several chemicals in detail, giving properties, composition and application. Wright Chemical Corp.

202 **Boiler Water Manual**—Factual information on standard methods of applying chemicals in the treatment of water for boilers is presented in this 16-pp technical bulletin, called Standard Method 122. Discusses pretreatment of raw water, application of chemical feeding to pretreating operations and both constant rate and flow responsive feeding direct to boiler drum and to feedwater system. Also discusses condensate returns, flushing periods. Proportioneers, Inc.

203 **Water Softening Equipment** — How the problems caused by hard water can be offset by the use of water softeners is explained in Bulletin 2386, 12 pp, describing ion exchange equipment. It covers in detail downflow, upflow and gravity zeolite water softeners. Contains a 2-pp cutaway illustration of a fully automatic softener. The Permutit Co.

205 **Boiler Corrosion**—A 12-pp article discussing the cause and prevention of corrosion in boiler systems is presented in Betz Technical Paper No. 111 titled "Corrosion: Its Effect in Boiler Systems." The corrosive effects of oxygen, carbon dioxide, ammonia, hydrogen sulfide, acidity and physical factors are evaluated. W. H. & L. D. Betz.

206 **Turbine Blade Deposit Study**—Identification and prevention of steam turbine blade deposits and boiler water conditioning to prevent such deposits are discussed in 16-pp Bulletin 28B7030. Describes x-ray diffraction methods for identification purposes. Tables list partial chemical analyses of deposits containing sodium disilicate, occurrence data on compounds found, composition of deposits. Allis-Chalmers Mfg. Co.

207 **Two-Stage Water Conditioner**—Bulletin 4801 describes company's water conditioner which combines the advantages of both hot process and zeolite softening. Explains operation of softener in which the first stage is the hot process using lime or Dolomitic lime and the second stage in which zeolite softener reduces hardness to zero. Cochrane Corp.

208 **Corrosion Treatment** — "Corrosion Protection of Steam and Condensate Return Systems" is a 4-pp folder covering amine treatment for inhibiting of boiler and condensate systems. This treatment is described as affording surface protection of the metal itself as well as raising the pH value of the condensate. Booklet gives specific case histories and typical economies obtained by power plants using this treatment. The Bird-Archer Co.

209 **Chemical Feed Systems** — Single, complete "packaged" units for feeding directly into boiler feed water lines are the subject of 4-pp Bulletin 4811. It covers various types of feeding, explains automatic control. Milton Roy Co.

210 **Modern pH and Chlorine Control**—This 100-pp booklet gives technical details of company's color comparators and equipment in water testing and control of boiler and industrial process water, also technical information on the meaning of pH control, electrometric and colorimetric methods of determining pH and also determining impurities in water; applications of water control in air conditioning; treating boiler feed water. W. A. Taylor & Co.

211 **Water Softeners** — Bulletins WC-102 is a 36-pp presentation of recent developments in hot-process water softeners. Explains boiler plant troubles caused by various impurities in water, outlines 12 methods of treating water to eliminate these impurities, describes reasons for the popularity of the hot-process method and its advantages, and explains the chemistry of hot-process water softening. Graver Water Conditioning Co.

212 **One-Minute Water Tests** — Rapid, simple and accurate tests for determining water hardness are described in Bulletin 1RE50, 4 pp. Procedures, reagents, and equipment are pictured and described. Bulletin tells how tests may be used to determine water hardness, hardness due to calcium alone and hardness due to magnesium alone. Hall Laboratories, Inc.

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In Canada . . . Tube Turns of Canada Limited, Chatham, Ontario

213 **Boiler Water Treatment** — Bulletin 47, 8 pp, is on internal treatment of boiler water. Defines internal treatment and tells its advantages in softening, sludge conditioning, stabilization. Explains operation of company's system, including the chemicals used. National Aluminate Corp.

215 **Ion Exchange Systems** — "Amberlite Monobed Deionization" is a 12-pp miniature textbook covering the history, behavior, present performance, and potential uses of the Monobed ion exchange systems in water-conditioning, chemical processing and other industries. Reactions of various combinations of exchangers are explained in text and equations. Also discussed are operating costs, equipment costs, quality of product derived, rinse requirements and other properties as they apply to the complete or partial single-step removal of ionized solids. The Resinous Products Div., Rohm & Haas Co.

BOILERS AND AUXILIARIES

216 **Shop-Assembled Boiler** — Eight-pp Bulletin G-72 introduces company's new integral furnace boiler. Describes and illustrates its economy, ease of installation and connection, flexibility, minimum space requirements, efficient combustion, fast steaming and ease of operation. The Babcock and Wilcox Co.

217 **Dowtherm Vaporizer** — Bulletin No. 46-2, describing manufacturer's Type "A" Dowtherm Vaporizer tells how this unit is designed to evaporate Dowtherm in such a way as to provide dependable operation at maximum temperatures, discussing its construction advantages in detail. The Wickes Boiler Co.

218 **The Why of Dual Circulation Generators** — The special advantages of company's dual circulation steam generator are presented clearly and factually in Bulletin B-50-11, 16 pp. Attractively illustrated with installation photos and sketches the text explains the principles of dual circulation. Tells the applications of this type of generator in both high make-up and low make-up plants. Foster Wheeler Corp.

219 **Tube Expanders**—Bulletin 280, 8 pp, covers manufacturer's line of tube expanders for maintenance of high pressure boiler tubes, superheaters, economizers, circulating tubes, steam generators other equipment. Thomas C. Wilson, Inc.

220 **Bent Tube Boiler Data**—This 20-pp booklet is filled with engineering drawings of recent installation of company's Class VL boilers, designed for adaptation to limited space conditions in plants having diverse steam requirements. Henry Vogt Machine Co.

221 **Rotary Tube Cleaners** — Bulletin R-105 presents air and water driven rotary tube cleaners and cleaner accessories. Illustrates several models and heads, discussing special features. Also includes data on motors, hose. Roto Div., Elliott Co.

222 **Fuel Economizers** — Both cast iron tube economizers and steel tube economizers are covered in detail in Catalog 169, 8 pp. Advantages of their diamond-shaped tubes and streamline flow of gas and soot blower steam are discussed. Green Fuel Economizer Co., Inc.

VALVES, TRAPS, PIPING

223 **Piping Materials Catalog**—Corrosion resistant valves and piping materials are covered in illustrated Circular 320, 32 pp. Contains information on manufacturer's complete line of valves, fittings, fabricated piping and pipe coils to meet a wide range of corrosive conditions. Listing includes both photos and cutaway drawing of models complete specifications, sizes and prices. Includes a description of alloy metals used. Crane Co.

224 **Valve Bulletin** — Catalog Section 12-H describes various types of company's cast steel pressure-seal bonnet valves. Information on choosing the best size valve for your service is given in one page of the booklet under the title, "Correlation of Valve Size and Pressure Drop." Design and construction advantages of the valves are given and tables of pressure and temperature ratings. Edward Valves, Inc.

225 **General Service Valves** — Bulletin E-160, 16 pp, describes and illustrates the design and construction of company's quick-operating valves, explaining their application to blow-off service and on fire protection, chemical process, soot blower, water column blow-down, and other types of pipe line. Included are tables of dimensions, weights and list prices. Everlasting Valve Co.

226 **Unions and Fittings** — Twelve-pp Catalog 50 covers manufacturer's line of unions of all types, elbows, tees and fittings. It describes and illustrates special construction features and other advantages. E. M. Dart Mfg. Co.

227 **More Data on Strainers** — Revised Bulletin S-263, 6 pp, contains greater and more up-to-date data on screwed strainers as well as expanded details on flanged types. Fully illustrated with photos of the strainers and screens used in them, it explains function of the strainers and provides material specifications, pressure and temperature data, dimensions and prices. Yarnall-Waring Co.

228 **Welding Fittings and Flanges**—Catalog and Engineering Data Book 211, a 282-pp manual, provides complete dimensional data, weights and prices on company's welding fittings and flanges. The engineering section contains practical information covering performance under varying conditions of temperature and pressure, location and materials processed. The technical section covers properties and rating of pipe, fittings and flanges, line expansion and flexibility, support and anchorage of piping and flow of fluids. Tube Turns, Inc.

229 **Steam Traps and Temperature Controls**—Here is a comprehensive catalog comprising many of company's bulletins on steam traps and related equipment, including an illustrated steam trap selection chart. Provides data on boiler steam traps, air eliminators, thermostatic steam traps and air vents, inverted bucket steam traps, temperature regulators and cooling controls, steam and water mixers, thermostats and strainers. Contains sizes, application data, prices. Sarco Co., Inc.

230 **Steam, Air, Gasoline Traps** — Th's 32-pp illustrated catalog, No. 250, describes five types of thermostatic steam traps for pressures to 225 lb; expansion steam traps for pressures to 250 lb; weight-operated traps for steam, air and gasoline service, pressures to 1500 lb; piston-operated steam traps for pressures to 650 lb, and also steam, air and gas separators. Includes capacity tables, installation diagrams. W. H. Nicholson & Co.

231 **Handbook on Fittings and Flanges** Catalog wf-1950, 88 pp, is packed with working information on seamless carbon steel welding fittings and forged steel flanges. In addition to presenting standard schedules with their specifications, list prices and sizes, book gives information on dimensional tolerances; American standard flange facings with dimensions; thread standards and threading practice; service pressure ratings, physical and chemical requirements for flanges, nuts and bolts; plus sizes and wall thicknesses of welding fittings in other metals. Grinnell Co., Inc.

232 **How to Choose and Use Air Traps** —Bulletin 202, 4 pp, describes manufacturer's complete line of air traps, covering their selection and installation for automatic drainage of moisture from compressed air intercoolers, aftercoolers, receivers, separators, and drip points. Prices included. Armstrong Machine Works.

233 **Rubber Expansion Joints** — Eight-pp Bulletin AD 137 tells about the application, construction, styles, service and advantages of the company's line of rubber expansion joints. Includes ordering information. The Garlock Packing Co.

234 **Flanges for Severe Service** — This 4-pp bulletin describes and illustrates a flange specially developed for services involving severe abrasion and corrosives, and for use in suction and discharge service. Photos and sketches illustrate the flange and its parts. Also covers a flexible rubber pipe for use with abrasive or corrosive material, and an acid- and corrosion-resistant duct. Goodall Rubber Co.

235 **To Make Valves Accessible** — This little folder describes a sprocket rim with chain guide. The rim adjusts to fit all valve wheels and makes them readily accessible. Prices given. Babbitt Steam Specialty Co.

INSTRUMENTS AND CONTROLS

236 **Control Linkage**—General Specification CA942, 16 pp, presents control linkage for company's control drive and also contains engineering price data. Explains and illustrates flexible control design drive levers, driven levers, connecting links, bearings and shaft and cable, also rotation over 90 deg. Bailey Meter Co.

237 **Boiler Water Level Control** — Bulletin 487 describes completely the installation of boiler water level control equipment at the Blackhawk Generating Station, Wisconsin Power & Light Company. Northern Equipment Co.

238 **Instrument and Control Panels** — Bulletin 773, 8 pp, explains how company's panels are made and where they are used. All operations of fabrication are discussed and illustrated—layout, cutting, drilling, welding, fitting, painting, wiring. The Hays Corp.

239 **Remote Reading Flow Meters**—Data Book 702, 32 pp, fully illustrates and explains flow measurement problems and offers suggestions for their solution. Meter bodies, differential devices and reading instruments are fully described. Republic Flow Meters Co.

240 **What's Going on Inside?**—Eight flow indicators for insertion into pipe lines carrying oil, steam, water, cooling liquids are described in Bulletin DD, 4 pp. Covers both cylinder and window types. Ernst Water Column & Gage Co.

241 **Flow Meters**—Bulletin 400-F2, 8 pp, features company's meter for measurement of steam, air, or gas flow in 1 or 1½ in. pipe lines, and designed for installation directly in the line being metered. Illustrated with photos of meter, sectional and dimensional drawings, the bulletin explains how meter operates, discusses its advantages. Builders-Providence, Inc.

242 **Pneumatic Metering Element**—Company's pneumatic machine used as the metering element in the measurement and control of steam, gas and liquid flow, liquid level, pressure differential and similar applications, is illustrated and described as to application and operation in Bulletin 2130. Hagan Corp.

243 **For Practical Men**—That's the title of this 24-pp pocket-size booklet presenting insulation testing in simple language. Packed with maintenance hints, it explains electrical insulation, tells how it can be tested and what makes it go bad. It describes the Megger insulation tester and justifies its cost in terms of long run economy and prevention of shutdowns. James G. Biddle Co.

245 **Flow Tube** — Catalog 80, 4 pp, presents engineering data on a new primary element for measuring, regulating and controlling fluid flow. Tells how these flow tubes are designed and how they function and discusses their advantages. Foster Engineering Co.

246 **Control Equipment**—General Catalog 001, 30 pp, is devoted to measuring and control equipment for water and sewage works, power and processing industries. Catalog illustrates and describes in detail: venturi tubes and meters, controllers, gages, manometers, pilot equipment. Simplex Valve and Meter Co.

247 **Pressure Regulator**—Bulletin 1-B, 8 pp, discusses design, operation and applications of a super-sensitive pressure regulator; shows typical installations. Also covers a compound regulator for controlling back pressure relief valve and high pressure make-up valve. Atlas Valve Co.

248 **Steam Calorimeter** — Company's U-path steam calorimeter which combines a throttling separating and re-evaporating calorimeter in a single chamber and offers extreme accuracy is described in Bulletin 118. Ellison Draft Gage Co., Inc.

249 **Air Locks**—Bulletin S-31, 2 pp, describing company's air locks and trip master controls for holding regulating and control valves in position during failure of air supply, is illustrated with photos, diagrams and line drawings. The Swartwout Co.

PUMPS, COMPRESSORS, ENGINES

250 **Centrifugal, Reciprocating Pumps**—This is a helpful collection of bulletins covering many types of centrifugal and reciprocating pumps for a wide range of services. Includes data on single-stage and multi-stage pumps, close-coupled

SUNVIS H.D. 700 OILS PREVENT AND CURE "THROMBOSIS" IN PRODUCTION MACHINERY

Reduced output and extra maintenance cost are the penalties when clogging occurs in the oil circulating system of machinery. But this costly production ill can be avoided. Sunvis H.D. 700 Oils *keep circulating systems clean.* What's more, if trouble exists now, Sunvis H.D. 700 Oils will *free oil lines and bearings of foreign matter.* They go to work immediately loosening up and carrying away any accumulation of dirt, carbon, water, or other contaminants.

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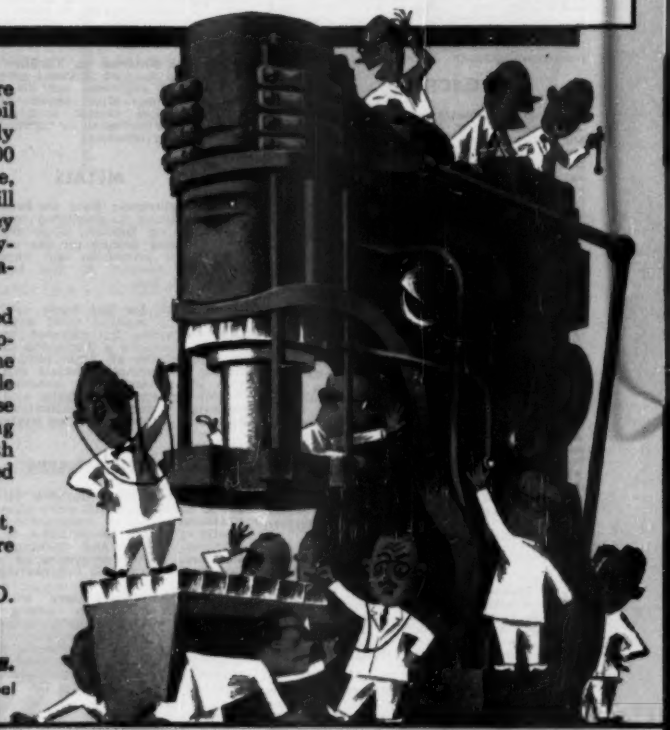

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pumps, high pressure pumps, pumps especially suited for handling erosive and corrosive liquids and others. Warren Steam Pump Co., Inc.

251 **For Many Pumping Jobs**—The Series A313A, latest of company's well-known IMO pumps and especially designed for low cost standardized, quantity production, is described in illustrated Bulletin L313A-B, 8 pp. This is a general service screw-type rotary pump for petroleum products and other light or viscous fluids as required for rotary and steam atomizing oil burners, oil transfer, lubrication, hydraulic systems and similar services. De Laval Steam Turbine Co.

252 **Compressor Selection Chart**—Here's a selection chart, based on normal applications handling air with atmospheric intake pressure. It simplifies selection of proper size compressor for average industrial use, with quick comparison between discharge pressure pounds per square inch gage and piston displacement cubic feet per minute and shows recommended compressor bore and stroke in inches. Worthington Pump and Machinery Corp.

253 **Air Compressor Lubrication Manual**—Valuable information on air compressor maintenance is contained in this 40-pp illustrated book. Subjects treated include compressed air, compressors and related equipment, lubricating systems, compressor oils and their applications, lubrication requirements, operating hints, oil requirements, storage and care of compressor oils, and safety precautions. Cities Service Oil Co.

254 **Modern Steam Engines**—In presenting steam engines as more than "just drives," Bulletin 306 touches briefly upon some of the advantages of "by-product" power. Bulletin features company's vertical steam engines of both throttling and automatic governor types. Troy Engine & Machine Co.

255 **Pump Packings**—Packings for use on reciprocating and centrifugal pumps are illustrated by photo and described in this 4-pp folder. It covers packings for practically all services and includes recommendations. Johns-Manville.

ELECTRICAL

256 **Power Factor Correction**—Examples illustrating basic considerations in the improvement of system power factor are contained in Bulletin GSB7465, 4 pp. It points out economical and operational advantages of improving plant power factor and advisability of keeping the load power factor up to 0.8 lagging or higher, and tells how the effects of low power factor can be corrected. Allis-Chalmers Mfg. Co.

257 **Synchronous Motors** — High speed synchronous motors are described in 4-pp bulletin PB 3400-1. The bulletin is packed with descriptive matter and photographs explaining features. Elliott Co.

258 **Low-Speed Synchronous Motors** — Publication GEA-3332, 8 pp, illustrates typical installations of efficient high-power factor, constant-speed drives, describes their construction features, and indicates mechanical modifications and performance data. General Electric Co.

259 **Care of A-C Rotating Equipment**—To promote intelligent and consistent maintenance of electrical machines, company has published Bulletin 05R7417, which is a series of articles by Fraser Jeffrey. Contents of the 24-pp booklet cover preventive maintenance and machine repairs, and such subjects as drying moist insulation, measuring insulation resistance. Allis-Chalmers Mfg. Co.

COAL HANDLING

260 **Spreader Stokers**—Catalog 80, 44 pp, describes a spreader stoker with forward moving grate that slowly and continuously discharges ash at the front. Explains the efficiency and economy of this stoker, illustrating grate's design and operation. Detroit Stoker Co.

261 **Coal Handling Equipment**—Modern equipment for the storage and handling of coal and ash is presented in 24-pp Bulletin 300. Illustrated, covers concrete and tile silos, cylindrical steel tanks, suspended steel bunkers. Clifford-Wood Co.

263 **Spreader Stoker Selection** — Fourteen-pp Form P-320-A10M is intended to help those choosing a spreader stoker to get the most for their investment, and it points out many factors to be considered. American Engineering Co.

264 **Spreader Stoker Data**—This is a file of three illustrated bulletins on spreader stokers. The first discusses seven reasons for selecting these stokers and describes their design, construction and operation; the second, dumping grates, the third, installations. Riley Stoker Corp.

265 **Coal Scale Manual** — Recently-published Bulletin 0130 describes automatic coal scale construction and operation, illustrating special design features which provide for high accuracy and long service. Richardson Scale Co.

FUEL OILS, LUBRICANTS

266 **Steam Power Plant Auxiliaries**—In Vol. 28, No. 4, of Lubrication, a technical publication on selection and use of lubricants, is an article on recommended lubrication practices for steam power plant auxiliaries. Discusses automatic coal firing machinery, stoker design, pulverizers, tube cleaners, compressors, motors, fans and blowers. The Texas Co.

267 **Diesels, Their Fuels and Lubricants**—This 46-pp book offers a well organized and attractive presentation of practical information on diesel engines, covering their history and economics as well as their design characteristics and operating principles. Classification of diesels according to speed is explained. Other chapters cover injection systems, combustion chambers, lubricating systems, and deisel oil purification and filtration. Includes a discussion of fuel and lubricating oil required. Sinclair Refining Co.

268 **Fuel Oil Treatment** — By text and sketches, this folder points out undesirable conditions in the storing, pumping, heating and burning of industrial fuel oil and the correction of these conditions by company's fuel oil treatment. E. F. Drew & Co., Inc.

269 **The Answers on Turbine Oil**—This 2-pp booklet answers several questions power engineers ask about turbine oils, including: What causes deposits of sludge? What causes acidity increase? What causes corrosion in turbines? Standard Oil Co. (Indiana).

METALS

270 **Engineering Data on Inconel** — In addition to providing extensive information on Inconel, 24-pp Bulletin T-7 also presents details on the composition, mechanical properties and physical constants of Inconel X. The International Nickel Co., Inc.

271 **Steels for Hot Spots** — This is an 88-pp manual filled with information on steels for elevated temperature service. Includes a discussion of the general principles of high temperature behavior of ferrous materials and the factors influencing their behavior; a data section replete with tabular and graphical material covering mechanical property values of 21 steels. United States Steel.

CONDENSERS

272 **Condensers** — Bulletin 441-C, 28-pp, covers in detail every phase of manufacturer's line of condensers—their simplicity of design, accessibility, construction features. Photos and drawings show assemblies, parts, principles of operation. Condenser Service & Engineering Co.

273 **Steam Condensers with Reserve Flow** — Eight-pp Catalog 410-1 describes a "self-cleaning" reverse-flow condenser for power plant service, designed to virtually eliminate cleaning down time and, in the case of divided water box condensers, eliminate operation at partial load. C. H. Wheeler Mfg. Co.

MECHANICAL POWER TRANSMISSION

274 **Transmission Belting** — Catalog M-9022, 28 pp, gives detailed design, engineering and performance data on transmission belting. Tables on belt speeds, arc of contact, friction, horsepower correction, and service factors are included. United States Rubber Co.

275 **Hydraulic Couplings** — Bulletin 3924 is Vol. II of "Progress in Power," a 24-pp collection of advertisements covering use of hydraulic couplings in power plants. American Blower Corp.

276 **Worm Gear Drive Manual** — Engineering and ordering data on company's worm gear drives is presented in 88-pp Book 2324. Illustrated with photos and sketches it discusses types of drives and construction features and provides selection tips. Provides ratings, dimensions, overhung and thrust loads. Link-Belt Co.

HEATERS, HEATING

277 **Tubular Heat Exchangers** — Bulletin 916, 32 pp, describes tubular heaters, coolers, condensers and heat exchangers and their features. The various types of shells, tube bundles, stationary heads and floating heads are explained. Includes tables showing characteristics of tubing, the thermal resistance of tubes and pipes of many different metals and alloys, and the specific gravity and pounds per gallon corresponding to degrees Baume and API. Also presents charts of specific heats of midcontinent crudes. Griscom-Russell Co.

278 **Water Heaters**—Illustrated 6-pp Bulletin 70, Section I, on instantaneous type water heaters contains detailed capacity and dimension tables for two-pass, four-pass and six-pass designs, with tube bundles removable for inspection. A typical piping hook-up is shown. Davis Engineering Corp.

279 **Fan Heater Bulletin** — Here's a 2-pp illustrated bulletin (No. 109) on a new high pressure steam fan heater designed for complete utilization of both sensible and latent heat of high pressure steam. Niagara Blower Co.

280 **Heat Exchangers** — Bulletin 11.0.080 describes air cooled heat exchangers for condensing or cooling of steam or process vapors, natural gas, jacket water, lubricating oil, quenching baths. Equipment Div., J. F. Pritchard & Co.

DUST COLLECTING

281 **Fly Ash Elimination** — Power engineers will find this 30-pp booklet outstanding among material on this subject. It presents manufacturer's "Multiclone" equipment (described as small-tube type of cyclonic dust collectors using centrifugal force for separating duct from gas stream) as a highly successful and economical means of separating fly ash—not as a panacea for all cinder and fly ash problems. Western Precipitation Corp.

282 **Dust Collecting Efficiency**—How the higher and narrower inlet utilized in company's tubular dust collector contributes to more efficient dust collecting is explained in this illustrated bulletin. Prat-Daniel Corp.

OTHER EQUIPMENT

283 **Turbine Catalog Collection**—This is a valuable collection of bulletins covering a complete description of solid wheel turbines. They feature cross section drawings of typical units for both moderate and high steam pressure conditions. Also cluded are data on speed increasing and speed reduction gears. The Terry Steam Turbine Co.

284 **Velocity Stage Turbines** — Catalog 52-195R, 8 pp, features turbines for mechanical drives designed to operate under all inlet steam conditions up to 600 psig and 750 F. Gives specifications, dimensions. De Laval Steam Turbine Co.

285 **Concrete Floors Q & A** — The detailed information contained in this booklet covers service experiences and late developments in this field. The information covers methods, materials used in placing corrosion resistant concrete. Lumnite Division, Universal Atlas Cement Co.

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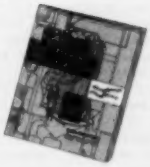

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POWER PLANT Construction News

Gantt, Ala.—Alabama Electric Cooperative, Inc., Andalusia, Ala., has plans under way for new steam-electric generating station in vicinity of Gantt (Covington County), with initial capacity of 15,000-kw, installation to include turbine-generator, boiler and accessory equipment. Cost about $3,600,000, including switching station, transmission lines, etc. Financing has been arranged through REA and work is scheduled to begin soon.

Selma, Ala.—Independent Lock Co., Cleghorn St., Fitchburg, Mass., locks and locking devices, and other hardware products, is considering construction of boiler house at proposed new branch plant at Selma, where site has been acquired. Plant will consist of a main one-story building and number of smaller structures, with machinery for large output. Entire project reported to cost close to $1,000,000.

Fontana, Calif.—Southern California Edison Co., 601 W. 5th St., Los Angeles, Calif., has acquired tract of 200 acres of land in vicinity of Etiwanda Ave., Fontana, as site for new steam-electric generating station. Initial installation will include two 100,000-kw turbine-generator units, with high-pressure boilers and auxiliary equipment. Boiler units will be arranged to use either natural gas or oil as fuel, with automatic combustion equipment. Completion is scheduled in 1952. Entire project will represent a reported investment of $30,000,000. With this new station, company has abandoned plans for proposed new generating station at Whittier Narrows, Los Angeles County, previously referred to in these columns.

Los Angeles, Calif.—Van Camp Sea Food Co., an interest of Van Camp, Inc., 1807 E. Olympic Blvd., Los Angeles, plans new central steam power plant on Cannery St., Terminal Island, Harbor district, to provide steam for processing for a group of five fish canneries. Cost estimated about $1,000,000. Proposed to begin work soon.

Eastport, Fla.—St. Regis Paper Co., 230 Park Ave., New York, N. Y., pulp and paper, plans power plant at proposed new kraft pulp and paper mill at Eastport, near Jacksonville, where large tract of land is being acquired. Project will comprise a group of one and multi-story buildings, with machinery and facilities for initial output of about 100,000 tons per annum. Entire program will represent a reported investment in excess of $10,000,000.

Terre Haute, Ind.—Public Service Co. of Indiana, Inc., 110 N. Illinois St., Indianapolis, Ind., will have plans prepared by Sargent & Lundy, 140 S. Dearborn St., Chicago, Ill., consulting engineers, for proposed new steam-electric generating station on Wabash River in vicinity of Terre Haute, recently referred to in these columns. It will be equipped for a capacity of 180,000-kw and is reported to cost close to $30,000,000, with transmission lines, power substations and other operating facilities.

Louisville, Ky.—Louisville Gas & Electric Co., 311 W. Chestnut St., will have plans prepared by Pioneer Service & Engineering Co., 231 S. La Salle St., Chicago, Ill., consulting engineer, for proposed expansion and improvements at Paddy's Run steam-electric generating plant, recently referred to in these columns. Work will include installation of new 60,000-kw turbine-generator unit and auxiliary equipment. Entire project is reported to cost close to $8,500,000, with power substations, transmission lines and other operating facilities. Proposed to begin work soon.

Annapolis, Md.—Bd. of Directors, St. John's College, Annapolis, has authorized new boiler plant for central-heating service at institution. Cost reported about $300,000. Plans will be prepared soon.

Detroit, Mich.—Memorial Hall Commission, J. E. Frawley, president, care of O'Dell, Hewlett & Luckenbach, Dime Bank Bldg., Detroit, architects, plans central-heating plant in new Henry and Edsel Ford Auditorium at Woodward Ave. and Jefferson St. Cost estimated about $2,500,000. Architects noted are in charge and will ask bids for construction in near future.

Clifton, N. J.—Nevins-Church Press, Inc., 92 Midland Ave., Glen Ridge, N. J., paper boxes and containers, plans boiler house at proposed new plant on Allwood Ave., Clifton, where tract of about 11 acres of land has been secured. It will be one-story, about 150,000 sq ft floor space. Entire project is reported to cost close to $1,000,000, with converting machinery and auxiliary equipment.

Columbus, N. C.—Deering, Milliken & Co., Inc., 240 Church St., New York, N. Y., rayon products, plans steam-generating plant at new woolen mill at Columbus, where tract of land has been selected. It will comprise a main one-story building and several auxiliary structures. Entire project reported to cost about $2,000,000. Construction will proceed at once.

Piqua, Ohio—Sefton Fibre Can Co., 3275 Big Bend Rd., St. Louis, Mo., fibre cans and containers, plans boiler house in connection with proposed new branch plant at Piqua, where site has been secured, to be one-story, about 50,000 sq ft floor space. Entire project reported to cost over $350,000.

Carlisle, S. C.—Clearwater Finishing Co., Clearwater, S. C., dyeing, finishing and bleaching of textiles, plans boiler plant at proposed new mill on Broad River, near Carlisle, where site is being selected. It will comprise several large one-story processing units, with smaller adjoining structures. Cost reported over $5,000,000, with machinery. Company is an interest of United Merchants & Manufacturers, Inc., 1412 Broadway, New York, N. Y.

Memphis, Tenn.—E. I. duPont deNemours & Co., Electrochemicals Dept., duPont Bldg., Wilmington, Del., plans power house at proposed new plant at Memphis for production of sodium cyanide. It will consist of several one and multi-story buildings for processing and general production, and miscellaneous structures. Entire project is reported to cost about $7,500,000, and will require 12 months for completion. Work will begin soon.

Alvin, Tex.—Phillips Petroleum Co., City National Bank Bldg., Houston, Tex., refined oils, gasoline, etc., plans boiler house at proposed new natural gasoline plant at Alvin (Brazoria County), where large tract of land has been secured. Project will comprise a number of processing units, compressor plant, pumping station, steel pressure tanks for storage and distribution and other operating facilities. Cost reported in excess of $5,000,000.

Beaumont, Tex.—Gulf States Utilities Co., Beaumont, is arranging an expansion program in plants and system for a 36 mos. period, 1950-52, inclusive, including increased generating capacity, power substations, transmission lines and other facilities. Program will include completion of two power station additions now in progress at Neches generating plant, Beaumont, and Louisiana station at Baton Rouge, La., respectively, with installation of two 60,000-kw generators at first noted, and a 40,000-kw generator unit at Baton Rouge. Completion of both projects is scheduled in 1952. Entire program for period mentioned is estimated to cost about $72,000,000.

Beaumont, Tex.—Texas Gulf Sulphur Co., Second National Bank Bldg., Houston, Tex., plans steam-electric power plant at proposed new sulphur mining and refining works in vicinity of Beaumont. Project will consist of a number of buildings, with equipment for large output and is estimated to cost over $4,000,000, of which approximately $1,000,000 will be used for power station.

Colorado City, Tex.—Texas Electric Service Co., Fort Worth, Tex., has approved plans for extensions in Diesel engine-generating station at Colorado City, with installation of new generating unit and accessory equipment to double present capacity. Cost reported in excess of $1,000,000. Will begin work at early date.

San Antonio, Tex.—San Antonio Public Service Bd., 201 N. St. Mary's St., plans expansion in municipal power plant at Leon Creek, near city, with installation of new turbine-generator unit, high-pressure boiler and auxiliary equipment. Cost reported close to $7,400,000. Proposed to carry out work soon. Gibbs & Hill, Inc., 450 7th Ave., New York, N. Y., is consulting engineer.

Port Angeles, Wash.—School Bd., Port Angeles, plans central-heating plant in new one and multi-story high school. Entire project reported to cost in excess of $1,000,000. Bids for construction are scheduled to be asked soon. Mallis, DeHart & Hopkins, Lyon Bldg., Seattle, Wash., are architects in charge.

Tacoma, Wash.—Dept. of Public Utilities, City Hall, plans new municipal hydroelectric power plant on Cowlitz River. Details of capacity and estimates of cost will be determined soon. Application for permission has been made to Federal Power Commission, Washington, D. C.

Albright, W. Va.—Monongahela Power Co., Fairmont, W. Va., and Potomac Light & Power Co., Hagerstown, Md., affiliated organizations (both subsidiaries of West Penn Electric Co., 50 Broad St., New York, N. Y.) plans joint construction of new steam-electric generating station on Cheat River, near Albright. It will have a rated capacity of 150,000-kw, divided into two 75,000-kw turbine-generator units, with high-pressure boilers and auxiliary equipment. Cost reported close to $20,000,000, including switching stations, transmission lines and other facilities. Completion is scheduled in 1952.

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Boiler Feed Water Control . . . Excess or Constant Pressure Control, Steam or Water . . . Liquid Level Control . . . Balanced Valves . . . Desuperheaters . . . Boiler Steam Temperature Control . . . Hi-Low Water Alarms.

Boiler Feed Water Control . . .

Fully-automatic continuous COPES feed means safe, economical boiler operation. Choose from three basic control systems:

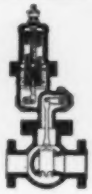
1. **SIMPLE LEVEL CONTROL** —one control influence
2. **FLOWMATIC CONTROL** —two control influences
3. **BALANCED FLOW CONTROL** —three control influences

1 SIMPLE LEVEL CONTROL

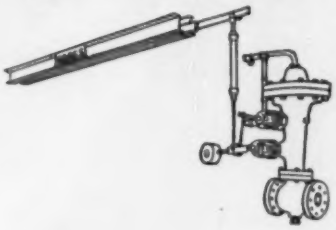
Feeds in response to drum water level changes. For moderate pressures and ratings. Type BI (*Leaflet P-1-D*) is standard. Type OT (*Leaflet P-2-A*) is the adaptation for small boilers.

PUMP GOVERNORS

For excess pressure service in boiler feeding. Special types for motor, or turbine-driven, centrifugal or reciprocating pumps. Master control available, where needed. Each unit designed for accuracy over a long service life under adverse conditions. Easily maintained. *Write for data, outlining your needs.*

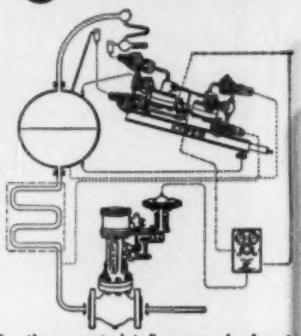


2 COPES FLOWMATIC



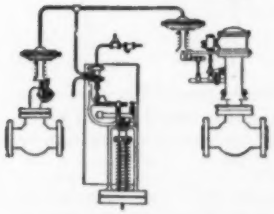
Simplest, most widely used flow-level type feed water regulator; more than 3400 boilers equipped. Feeds according to steam flow and water level to control level closely on fast-steaming generators, on any boilers taking rapid load swings. Easily adjusted and maintained by boiler room personnel. Direct-operated Type D-O, *see Bulletin 429-B.* Relay-operated Type R-O and air-operated Type A-O, *see Bulletin 441.*

3 BALANCED FLOW



Has three control influences—feed water flow, steam flow and water level. Ideal for the ultra-modern high duty steam generators. Independent of other boiler instruments and controls; will remain on full-automatic when they are out of service for routine servicing. Can control through hydraulic couplings. *Leaflet P-25.*

PRESSURE REDUCING VALVES



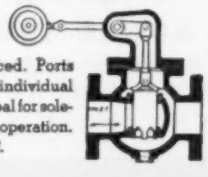
Built for jobs too tough for ordinary stock valves. Each is individually designed for your specific needs, with accuracy and dependability guaranteed. Quiet in operation. Direct or relay operation —with master control if desired. Pressure drops up to 2500 psi. Sizes to 14-inch. *Bulletin 477.*

DESUPERHEATERS

As accurate on light flows as on maximum loads. Complete atomization of cooling water over full range of operation, because flow is controlled at point of dispersion, not by any outside valve. Easy maintenance. Complete unit self contained. *Bulletin 405-B.*

BALANCED VALVES

Practically frictionless, closely balanced. Ports designed for individual installation. Ideal for solenoid or float operation. *Leaflet P-3-B.*



BOILER STEAM TEMPERATURE CONTROL

Holds uniform steam temperature under all load conditions. Sprays water into steam through variable-orifice nozzle between superheater stages, according to outlet steam temperature and rate of flow. Designs for boilers with heat exchangers. *Write for data, outlining your conditions.*

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For open or closed vessels. Improved float chambers or flange-type floats, with mechanical or fluid connection to COPES balanced valves. Pressures to 400 psig. *Write for details.*

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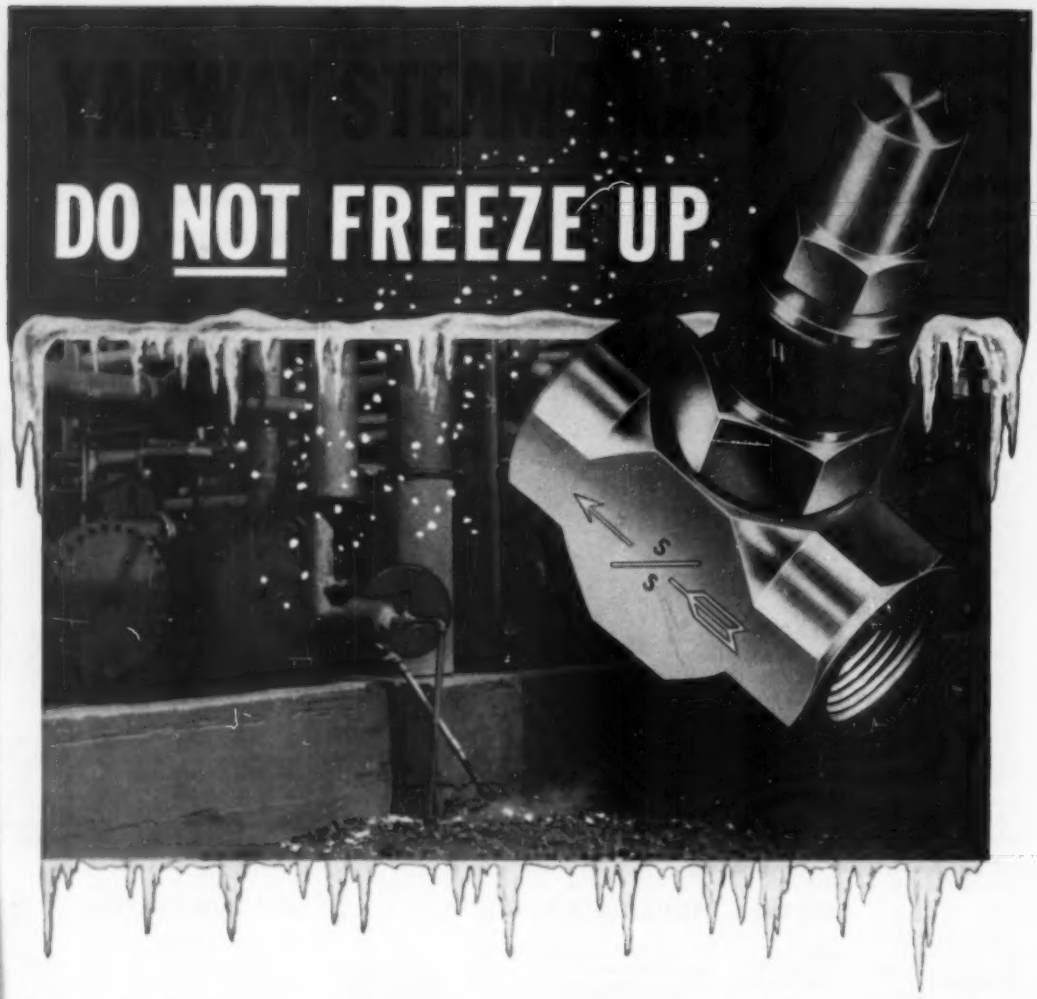

What if it is freezing cold—your exposed steam traps won't cause you any worry if they're Yarway.

Yarway Impulse Steam Traps don't freeze because condensate does not accumulate. The only moving part—a little valve—is continually testing for condensate and passing it as soon as it forms. It never waits for a trapful to collect. Hence, there's never anything to freeze.

There are other good reasons, too, why more than 650,000 Yarways have been bought for both indoor and outdoor installations.

They get equipment *hotter, sooner.* They are *small in size, light in weight, easy to install and maintain.* They are *good for all pressures.* Construction is *stainless steel.*

Prove these advantages in your own plant at our expense. Try a Yarway *for free.* Call your nearby Yarway distributor or write direct to . . .

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YARWAY IMPULSE STEAM TRAP

LETTERS TO THE EDITORS

ON USE OF CONSTANTS

IN HIS ARTICLE on Engineering Constants (POWER ENGINEERING, October, 1950, p. 82) Mr. Engelman states that many persons have "trouble or great inconvenience in using formulas with constants, so frequently found in engineering handbooks." No truer words were ever written and the sad part is that the formulas were written as they were in the belief that the form would enhance their convenience. The difficulty lies in the fact that a very large number of such formulas violate the basic principles of dimensional analysis.

Outside of the purely mathematical equations, such as those of trigonometry, the formulas are *physical* equations. A physical equation expresses the relationships existing in some particular phenomenon. Physical equations may be empirical or rational but, if they are to be correct, they *must* be homogeneous in their dimensions. What is meant by homogeneity of dimensions may be illustrated by some examples.

The Williams and Hazen formula, for the head-drop in a pipe, with the value of the constant C taken as 100 and the value of the hydraulic radius, R, for round pipes, can be reduced to:

$$H_f = \frac{0.002068\ (Q)^{1.85}}{(d)^{4.87}}$$

where

H_f is in feet
Q is in gallons per minute
d (diameter) is in inches

If the equation is written for the dimensions alone, thus:

$$ft = \frac{g \times p \times m}{in.}$$

it is seen at once that the two sides of the equation are completely incompatible. No manipulation of the right side will yield feet which is the dimension of the left side. The formula will give the correct numerical result but the equation itself is not homogeneous as to dimensions and, therefore, is dimensionally incorrect.

The Darcy equation for the head-drop in pipes is written:

$$H_f = f\frac{L}{D} \cdot \frac{V^2}{2g}$$

where

H_f is in feet,
f is a dimensionless constant akin to the coefficient of friction,
L is in feet,
D is in feet,
V is in feet per second,
g is in feet per second^2.

Written in terms of the dimensions alone, this equation appears as

$$ft = \frac{ft}{ft} \cdot \frac{\frac{ft^2}{sec^2}}{\frac{ft}{sec^2}}$$

from which it may be seen that the right side reduces to feet and, hence, is completely compatible with the left side. The f was omitted from the dimensional equation because it is dimensionless and so has no bearing on the dimensions of the right side. From this it is clear that the Darcy equation is homogeneous and, therefore, correct.

It is amazing to find how few engineers realize *exactly* what is implied in equations containing dimensions. Five feet is *not* five times a foot; five feet is a distance which is five times as large as the unit of measurement, the foot. The number 5 is the ratio between the measured distance and the unit of measurement and, hence, is a pure number; it has no dimensions.

No purely arithmetic number can be used to operate on another number unless it too is a pure number. Since a ratio is a pure number it may be operated on by other pure numbers such as sin or log.

If 550 lb is raised through a distance of 600 ft we say that 330,000 ft-lb of work have been done. We should write the expression in this form:

$$\underset{\text{numbers}}{(550 \times 600)} \qquad \underset{\text{dimensions}}{(ft \times lb)}$$

keeping the pure numbers and the dimensions as separate items. If this work had been done in one minute then we would have,

$$(550 \times 600) \qquad (ft \times lb\ per\ min)$$

and if this is divided by the constant for horsepower we arrive at,

$$\frac{(330{,}000)}{(33{,}000)} \times \frac{(ft \times lb\ per\ min.)}{(ft \times lb\ per\ min.)} = 10$$

which is a pure number expressing the ratio between the measured quantity and the unit of measurement, in this case, defined as a horsepower.

In many of the handbook equations, important dimensions have been submerged in the "conversion constants" and this is the very thing that causes all the trouble. It is only by being constantly aware that all numbers, in a physical equation, are pure numbers (expressing the ratio between the measured quantities and the units of measurement) and by strict attention to homogeneity of dimensions that one can eliminate confusion and avoid serious errors.

F. W. KEATOR

THE FLUX ALGEBRA—A CORRECTION

Our attention has been directed to several typographical errors in the article "The Flux Algebra" By William O. Ordinanz which we published on page 62 of the August issue. These are as follows:

Page 62 left column, 14th line from below, per deg. K should read per deg. K^4.

Page 63 left column, 12th line from below. $\varphi_{1-2} + \varphi_{1-3}$ should read $\varphi_{1-2} = \varphi_{1-3}$

Page 65 right column, 11th line from below, boiler tubes should read boiler tubes Ft.

7-LEAGUE GLOVES

THE REFERENCE on page 73 of the October issue to valves in inaccessible places, and the remedies therefor, set me to overhauling my memory on this subject, with the result that I am sending two sketches about a job I assisted in laying out.

During the war days, between the necessity of getting a new turbine into service in our plant in the shortest possible time and the difficulty of obtaining the necessary materials, extension valve stems were run vertically from five valves through pipe sleeves to floor stands on the operating floor above. While satisfactory for operating the valves, the promiscuous locations of the floor stands gave a very messy appearance to the turbine room, and blocked the passage between the end of the turbine and the turbine control board.

When the construction rush was over and materials were readily available, it was decided to relocate the floor stands and install extension controls. As four more turbines were ultimately to be installed in this plant, with their shafts parallel, the floor stand arrangement for the first turbine was to be standard for the entire power plant.

The valve stand for the 6-in. condensate recirculating globe valve was on a line 2 ft back from the steam end of the turbine. As this was a very satisfactory location, it was decided to relocate the other

(Continued on page 90)

National Container *Installs 625 lb Plant at* Tomahawk

New 625 psi steam generating unit, together with 5000-kw double extraction condensing turbine generator, makes it possible for the power plant at the Tomahawk, Wisconsin, Kraft Board Mill of the National Container Corp. to produce all steam and electricity needed during normal operation. A feature of the new installation is the very complete feedwater treating system employing a new method of sludge recirculation in the lime-soda ash softener

By **J. E. HOEFT**, Power Plant Superintendent[1], National Container Corp., Tomahawk, Wis.

THE NATIONAL Container Corp. of Wisconsin, located at Tomahawk, Wisconsin, is part of a national organization—The National Container Corp., with board mills at Jacksonville, Florida; Big Island, Virginia; and Ontonagon, Michigan, in addition to this mill at Tomahawk, Wisconsin. There are also sixteen box plants, which convert the board into corrugated shipping containers, located at strategic points throughout the country.

In the manufacture of pulp and paper, there is a tremendous demand for electric power and process steam. We use process steam at two pressures; 150 lb for cooking wood chips, and 50 lb for drying the board and for heating the mill.

Until recently, process steam was provided by:

1. Four Wickes vertical, water tube boilers rated at 12,000 lb of steam per hr. Three (Nos. 1, 2 and 3) are fired with Hoffman Firite spreader stokers and one (No. 4) with a Combustion Engineering Type E Underfeed stoker.
2. One Babcock & Wilcox Type H Sterling boiler (No. 6), rated at 30,000 lb of steam per hr and fired with Hoffman Firite spreader stokers.
3. One Babcock & Wilcox Type H Chemical Recovery Unit (Boiler No. 5), rated at 75-ton capacity (26,300 lb steam per hr).

All steam was generated at 150 psig and the 50 lb steam was made up through pressure reducing valves. Roughly, a third of the process steam was generated by burning Waste Heat fuels. That is, bark and wood refuse burnt in either boilers 4 or 6 and black liquor burnt in the Chemical Recovery Unit boiler No. 5.

Electric power was obtained from our Hydro Electric Plant at Grandmother Dam on the Wisconsin River, rated at 3600 kw with the rest of the demand being purchased from the Wisconsin Public Service Corp.

Early in 1948, plant expansion together with obsolescences of boilers 1, 2, 3 and 4 dictated the need for additional steam and electric generation. A careful study showed the need of 5000 kw generation. Accordingly, a 6250 kva double extraction condensing turbine generator with extraction pressures of 150 and 50 psig to provide process requirements was installed.

To meet the additional steam re-

[1] Registered Professional Engineer.

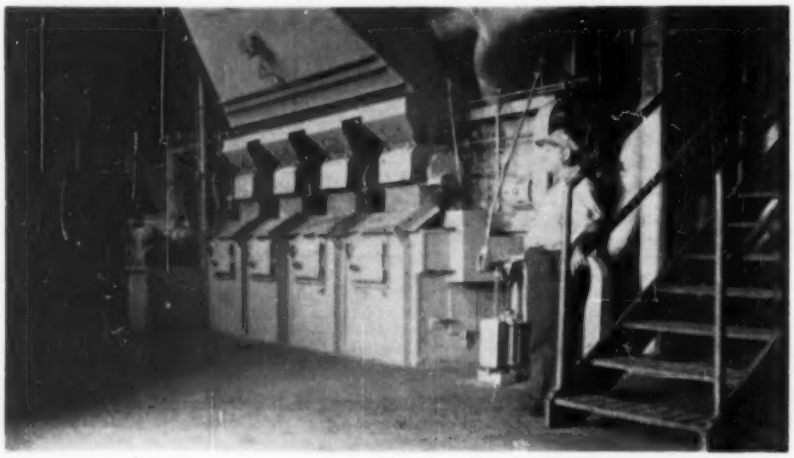

Fig. 1. A view of the boiler front of the new 625 psi unit. This is a 90,000 lb per hr boiler fired by a Firite spreader stoker. This boiler alone produces the high-pressure steam for the new 5000-kw turbine-generating unit

quirements for electric generation and process demand, a 90,000 lb per hr boiler, 700 lb design pressure, 700 F total steam temperature was installed (boiler No. 7). This boiler, with its watercooled furnace, is designed to burn any good grade of bituminous coal.

Going to high pressure steam generation, with 36 per cent make up water and using Wisconsin River water for make up, necessitated a good feedwater treating system. Upon the recommendation of our feedwater consultants, Hall Laboratories, we installed a Hot Lime-Soda Ash softener with preliminary clarification and with a secondary phosphate softener.

A complete new coal handling and storing system was also installed.

The new power plant, shown in Fig. 9, is of brick and steel construction. It contains the old boilers still in service, the new high pressure boiler, the new turbine generator, the feedwater treating system and the coal handling equipment. This building and the equipment was built around three sides of the old Boiler Room and then tied into the old plant without interfering with production.

The various boilers and turbines are connected with steam headers as indicated in Fig. 5. In all, there are seven boilers including the recovery unit operating at three different boiler pressures. However, most of the load is carried by the new high pressure boiler. Normally, boilers 4 and 6 are also kept in operation since they are equipped to burn bark and since No. 6 is the only one designed at a high enough pressure to supply the new 185 psig process steam requirement. Boilers 1, 2 and 3 are retained as standbys and are used during high load periods only.

The four old boilers — numbered 1 to 4 — as well as the recovery unit No. 5 all generate at 150 psig and operate in parallel with the 150 lb extraction point on the turbine generator. This 150 psig system feeds a process steam line; a 300 hp turbine driving a high pressure boiler feed pump; the two paper machine drive turbines (350 hp and 400 hp). Very close pressure control is necessary on this header. This is maintained by the extraction governor on the turbine.

The three mechanical drive turbines, fed by the 150 psig system, exhaust into the 50 psig system. The balance of the 50 lb steam requirements is supplied by the 50 lb extraction point on the turbine generator. Here, too, very close pressure control is maintained by the extraction governor. Some 50 lb steam is passed through a pressure reducing valve to 6 lb for water treating. However, most of the 6 lb steam is made up by flash steam from the paper machine condensate returns.

Boiler No. 6 operates at a pressure of 185 psig to supply process steam. Excess steam generated by this boiler is bled through a pressure relief valve into the 150 psig line.

Both the 150 and 50 lb extraction points on the turbine are fully protected against outage or low-stage pressures by a 650-150 lb pressure

Fig. 2. A view in the turbine room showing the turbine control panel at the right and the 60-cell storage battery at the far end of the room. The turbine can be seen at the left

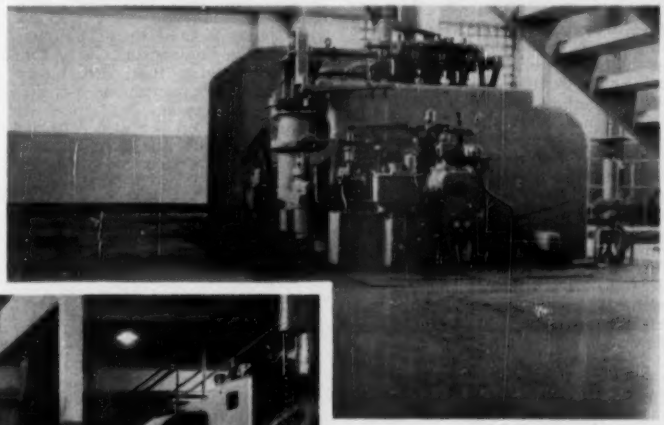

Fig. 3. (Above) Looking at the steam end of the new turbine generator unit. This is a 6250 kva, machine consisting of a 15-stage double extraction, 625 psi, 700 F TT, condensing turbine coupled to a 4160-v, 3-phase, 60-cycle generator

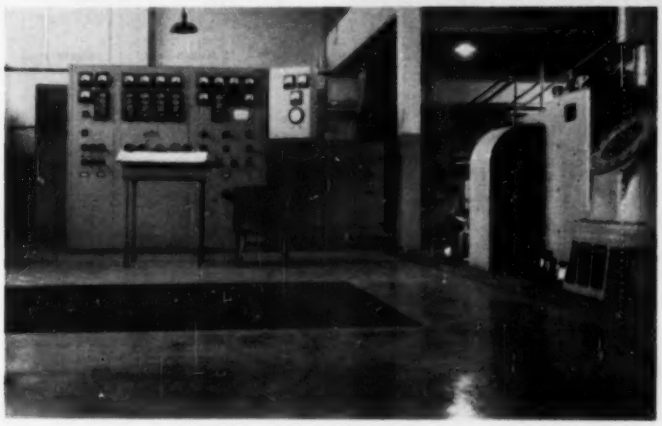

Fig. 4. (Left) Another view in the turbine showing the electrical control board and the turbine at the right

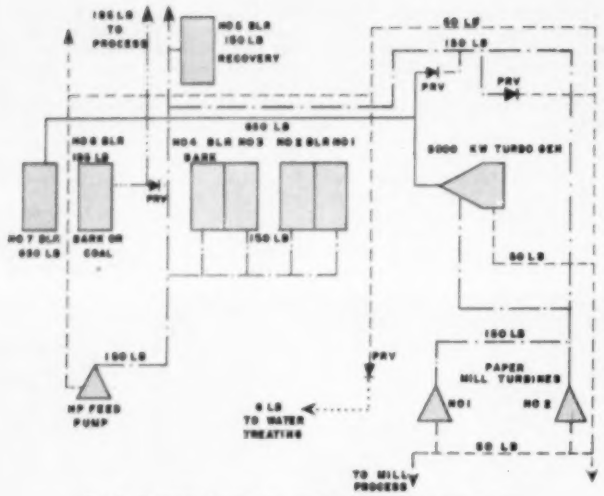

Fig. 5. Diagram showing the arrangement of the steam system

reducing valve and a 150-50 lb pressure reducing valve. These are used during emergency, only, but are necessary because of the importance of maintaining close control on these header pressures.

The new boiler operates at 650 psig and supplies steam for the turbine generator. However, at high extraction loads this boiler does not have sufficient capacity to fully load the generator. Our next expansion step, the installation of a 650 lb pressure recovery unit, which is now in progress, will enable us to operate at higher generator loads without calling on the old boilers.

The plant electrical demand is now largely met by generation with the new turbine generator augmented with generation at our Grandmother Dam Hydro Plant, located five miles down the Wisconsin River from the mill. We still maintain our tie-in with Wisconsin Public Service, and purchase power during periods of high plant load or low hydro production. We also produce hydro power for Wisconsin Public Service during periods when our mill is shut down.

A simplified diagram of our electrical connection is shown in Fig. 10. It will be noted from this that our transmission from our hydro Plant and our tie with Public Service is at 44 kv. The mill uses power at 4160 v and at 440 v, and we have transformers between these voltages and the 44,000 v system. The 44,000 v to 440 v transformers are part of the old power system. The 44,000 v to 4160 v transformer was added with the new power plant.

Our new generator produces power at 4160-v for transmission to load centers throughout the mill. Excess generation goes out through the 44,000-4160-v transformer, or power shortages on the 4160-v system are made up through the same transformer. Under average conditions, the power distribution on the two voltage systems is such that very little current passes through this transformer.

The New Generating Unit

The new generating equipment consists of a 90,000 lb per hr, 700 psi, 700 FTT Babcock & Wilcox Co. boiler, with superheater, and a continuous tube type economizer with multiple connection to the drum. This boiler is fired by a Hoffman-Combustion Engineering Corp., Firite stoker with four distribution units and with continuous ash discharge. Both stoker and grate are motor driven but are also provided with a Coppus auxiliary turbine. Fig. 1 shows a view of this boiler front.

This boiler has both forced and induced draft fans and is provided with a fly ash precipitator. The fans are American Blower Corp. fans, the forced draft units having inlet vane control and driven by a 50 hp General Electric motor. The induced draft fan has inlet damper control and is driven by a 200 hp G-E motor. The fly ash precipitator is the American Blower Corp., type ST.

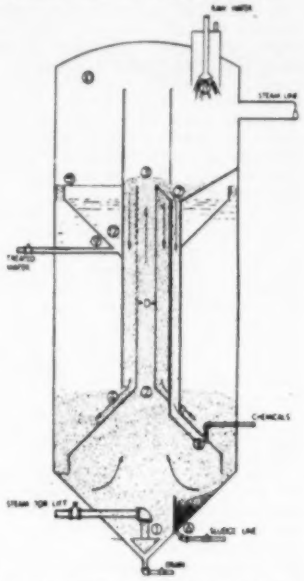

Fig. 7. Hot Process Lime-Soda Ash Softener with steam lift for sludge recirculation

This new boiler is provided with Bailey automatic combustion control, the control being centered on a control panel installed directly in front of the boiler.

The following fittings and accessories are installed:

Yarway water columns and Yarway tandem blow-off valves.

Consolidated safety valves

Bailey, 2-element feedwater regulator

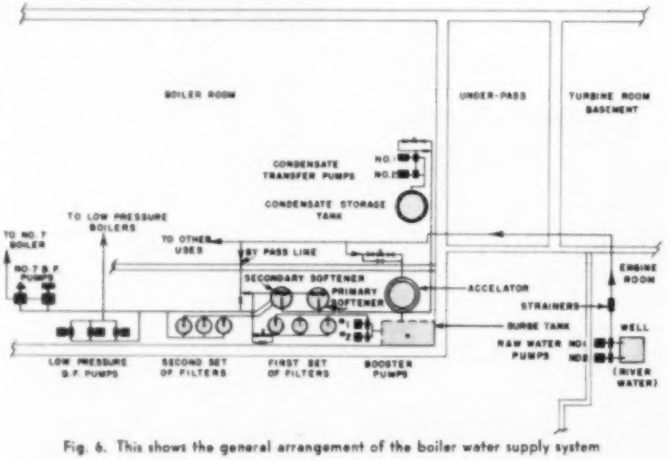

Fig. 6. This shows the general arrangement of the boiler water supply system

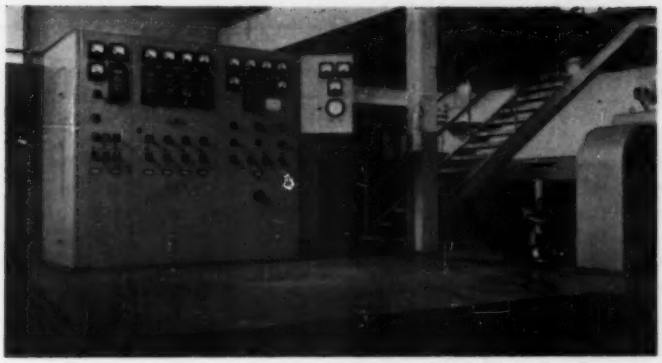

Fig. 8. (Left) A close-up view of the electrical control panel in the turbine room

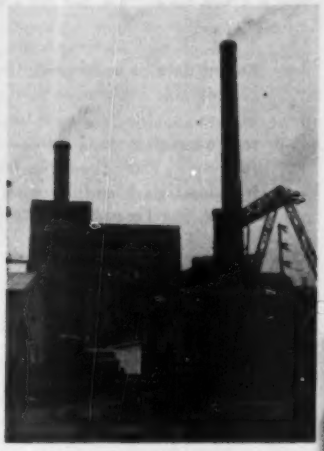

Fig. 9. Exterior view of the new power plant at Tomahawk

Edward non-return and other small valves

Powell boiler vent valves

Ash is handled by an 8 in. Steamatic United Conveyor system.

A new stack was erected to serve the new boiler. This is 8 ft in diameter, 80 ft high of steel, and is supported on the building steel above the boiler. This stack also handles the gasses from No. 6 boiler. The other boilers are still served by the old brick stack on the old section of the Boiler Room.

Coal Handling

Coal is delivered to the plant by railroad and from a track hopper; is fed into a pan feeder and then to a flight conveyor. Next, a bucket elevator carries it to the top of the Boiler House where another flight conveyor, across the tops of the bunkers, delivers the coal into a 370 ton parabolic bunker. From the overhead bunker, it passes through a Richardson automatic coal scale and then into the stoker hopper through a Stephens-Adamson non-segregating coal spout. All coal handling equipment was furnished by Stephens-Adamson. The system includes a 24 by 18 in. Knittel flying ring type coal crusher.

To prevent the coal from hanging up in the outlets from the overhead coal bunker, a distributing cone was designed and installed just below the discharges from the flight conveyor which distributes the coal to the bunker. This device, shown in Fig. 11, has proved very effective.

Coal is stored in a pile alongside the track hopper by a Diesel track crane and is reclaimed by bulldozing it into the track hopper. There is room for about 3500 tons in this storage pile.

Feedwater System

The feedwater treating system is interesting because of its completeness and, also because it makes use of a new method of sludge recirculation in the hot process softener. The entire feedwater treating system was designed by Infilco, Inc., and its general arrangement is shown in Fig. 6.

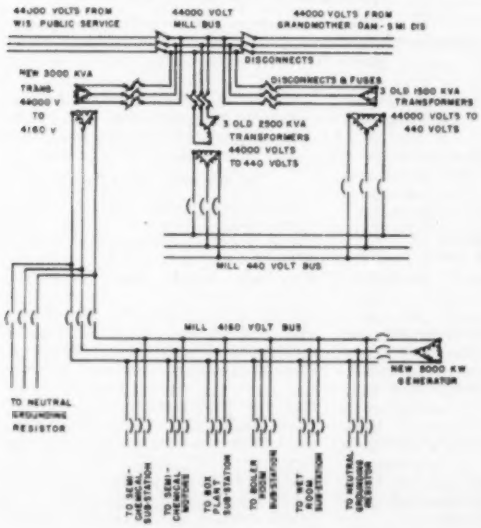
44,000 VOLTS FROM WIS. PUBLIC SERVICE
44000 VOLT MILL BUS
44000 VOLTS FROM GRANDMOTHER DAM - 8 MI DIS
DISCONNECTS
DISCONNECTS & FUSES
NEW 3000 KVA TRANS. 44000 V TO 4160 V
3 OLD 1500 KVA TRANSFORMERS
44000 VOLTS TO 440 VOLTS
3 OLD 2500 KVA TRANSFORMERS
44000 VOLTS TO 440 VOLTS
MILL 440 VOLT BUS
MILL 4160 VOLT BUS
NEW 5000 KW GENERATOR
TO NEUTRAL GROUNDING RESISTOR
TO SEMI-CHEMICAL SUB STATION
TO SEMI-CHEMICAL MOTORS
TO 60S PLANT SUB STATION
TO BOILER ROOM SUB STATION
TO WET 60S SUB STATION
TO NEUTRAL GROUNDING RESISTOR

Fig. 10. Simplified diagram of the electrical connections

Raw make up water first passes through an accelator where suspended solids and color are removed by an alum and activated silica floc. The clarified water is then pumped through primary pressure filters for removal of possible floc carryover, through the vent condensers on both secondary and primary softeners and into the primary softener where it is brought up to temperature by a spray heater.

The primary softener is a conventional Hot Process Lime and Soda Ash Softener, employing a steam lift for sludge recirculation and to provide intimate mixing of the raw water and chemicals. A section through the softener is shown in Fig. 7. The steam lift is similar in principle to the well known air lift except that steam is used instead of air. Referring to the diagram, steam for lifting purposes enters through a special nozzle at Point 1 and the finely broken up steam bubbles rise through the mass of slurry up tube 2. The mixture of steam and slurry in the center tube is, of course, lighter than the liquid outside of this tube and sets up a pumping action, causing the slurry to overflow at the top of tube 2 at Point 3 and it then circulates downward as indicated into the pool of slurry at Point 4 and back into the lower mixing chamber.

The raw water, entering at Point 11, is heated and sprays into a pool of slurry at Point 7, and the mixture of slurry and raw water flows down into the primary mixing chamber where chemicals are added at Point 8. The design is such that a portion of this circulating slurry spills over

(Continued on page 112)

Underground Hydroelectric Plants

Recent data on underground hydroelectric plants, which have been built all over the world, should be of considerable importance to American designers . . . They have almost become the rule for new plants in Europe . . . They are built because they cost less than surface plants at same location, since European rock excavation costs are low . . . Protection from attack an added advantage, but not built for that reason . . . Plant capacities from 31 hp to 2,800,000 kw, heads 17.7 ft to 3540 ft; run-of-river, storage, base-load, peak-load; pumped storage . . . Swedish plants cost $80 per kw . . . Discussion of operating factors . . . Experience of 10 yr with Italian plants yields important data on ventilation and illumination

UNDERGROUND hydroelectric plants installed in various countries, principally in Europe, have recently attracted considerable attention in the United States. Engineers in this country have not used them to any great extent although it is pointed out that the hydraulic turbine draft tube and discharge tunnel are often installed in spaces excavated from solid rock. However, the European and other foreign underground hydroelectric plants are installed entirely underground, in spaces excavated entirely from solid rock or, as in several cases in Italy, in caves enlarged for the purpose. These underground installations include turbines, generators, controls, transformers—the complete generating plant.

Furthermore, these plants were not built underground to protect them from aerial bombing or other attacks. They were built there because such construction was cheaper. Even when costs of ventilating and equipment handling are included, the lower cost of rock excavation in Europe results in a total plant cost lower than that of conventional surface plants at the same locations.

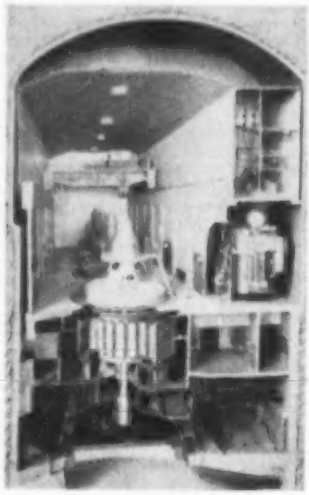

Fig. 1. Cutaway model showing an installation of five 56,000-hp Oerlikon hydroelectric generating units in underground plant at Innerthirchen, Switzerland (Courtesy *Civil Engineering*)

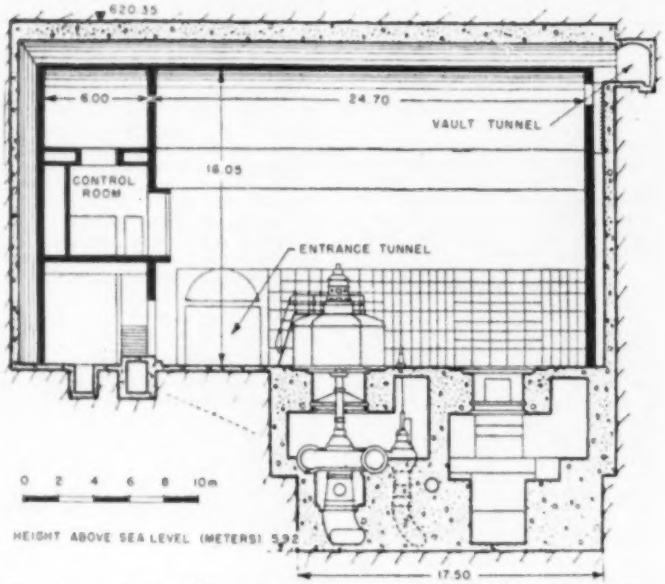

Fig. 2. Cross-section of underground hydroelectric plant at Agardo, Italy (Courtesy *Electric Light & Power*)

Rapid Development of Underground Plants

Recently a review of 60 underground hydroelectric plants in various parts of the world, having a total capacity of over 7,000,000 kw, was given before the ASCE by Joseph D. Lewin[1], as reported in *Civil Engineering*. There has been rapid development of underground power plants all over the world since the first one was placed in operation at Buchbergmuehle in Germany in 1907. This seems to indicate their basic economic soundness and operational advantages.

Neither geographic, climatic, nor topographic factors seem to limit the use of underground hydroelectric plants, according to Mr. Lewin.

All Elevations—All Types

From above the Arctic Circle, where the Swedish Porjus and Harspranget plants and the Russian Niva plant have been built, to southern Italy, where the Flumendosa plant is situated, from the Sulak in the eastern Caucasus to the Brommat and Baton plants in France, underground plants spot the globe. Even south of the Equator, in Peru and Australia, there are such developments. Underground power plants have been built at all elevations, from 7000 ft above sea level to the Niva plant just south of Murmansk, which discharges below sea level into Kandalaksha Bay. The units range from a 31-hp unit in Fried-

Table showing representative underground hydroelectric power plants

Plant	Country	Installed or design capacity, kw	Gross head, ft	Turbines	Powerhouse, net cu yd per kw	Initial operation, Year
Porjus	Sweden	60,000	183	8, Francis, hor	0.58	1910
Brommat	France	186,000	855	6, Francis, vert	0.32	1932
Innertkirchen	Switzerland	210,000	2235	5, Pelton, vert	0.28	1942
San Giacomo	Italy	200,000	2140	3, Pelton, hor	0.19	1948
Provvidenza	Italy	150,000	838	3, Francis, hor	0.29	1949
Lavey	Switzerland	72,000	130	3, Kaplan, vert	—	1950
Handeck II	Switzerland	114,000	1518	4, Pelton, vert	0.34	1950
Harspranget	Sweden	377,000	346	4, Francis, vert	—	1951
Santa Massenza	Italy	284,000	1505	—	—	—
Monte Argento	Italy	66,000	464	3, Francis, vert	0.32	1952
Montorio	Italy	100,000	845	3, Francis, vert	0.29	—
Verbano	Switzerland	100,000	973	4, Francis, vert	0.33	1952

igen, Germany, to a 2,800,000-kw development on the Snowy River in Australia.

Hydrostatic heads range from the 17.7 ft head plant at Friedigen to the 3,540-ft-head development at Tyin in Norway. Water quantities vary from the 15 cfs at Foce Ponale, in Italy, to the 14,200-cfs plant at Harspranget in Sweden.

These plants are built in all types of rock, igneous, sedimentary and metamorphic. Some are built in excellent, hard, sound rocks like the granites of Sweden, requiring practically no support; a few have been built in badly fissured, even disintegrated rocks, which required substantial and nearly continuous roof supports.

There are run-of-the-river plants and storage-fed plants; base-load and peak-load plants. There are even two pumped-storage plants — the Swiss Palue and the Italian Coghinas. No matter how different these plants are in regard to size, location, layout and operation, they have one thing in common. They represent the most economical solution for the development of power resources at the particular site.

Although underground hydro plants are more immune to aerial bombardment than surface plants, this consideration was not given much importance, since the majority of them were constructed before strategic bombing was developed during the last war. The final decision to place plants underground was primarily an economic one.

Analysis shows that costs are as much as 40 per cent less than conventional surface developments, most of the savings being due to shorter developments, elimination of penstocks and valves, and savings in tunnel linings. Rock is utilized as a structural material and made to carry loads. Underground developments require less operating expense; there is no painting, no roofing, no heating, and only a small depreciation charge. The cost of excavation is 90 per cent of the investment.

Economical European Rock Excavation

The seemingly paradoxical fact that the underground developments can be attributed to more economical methods of excavating rock in Europe. Based on prevailing American labor costs, it appears that European tunneling methods may reduce the cost of rock excavation by as much as 60 per cent.

A new development in lining circular pressure tunnels is the use of prestressed concrete. The lining consists of precast blocks 1½ to 4 in. thick, placed in the tunnel to form a full ring, which is then prestressed by high-tensile-strength steel loops or by high-pressure grouting in the space between the rock and the ring. The concrete is prestressed to a compression 50 per cent higher than the expected tensile stress. The blocks may also be treated with asphalt to improve their watertightness and to reduce friction losses. The thin prestressed linings reduce the required excavation and contribute toward further savings.

Underground powerhouses are adapted to architectural treatment. The domed structures are suited to indirect lighting and air conditioning. A compact turbine generator unit has been designed by the Swiss Oerlikon Co. to decrease the overall height of powerhouses and to simplify the support of the unit itself.

A similar discussion of these underground plants was recently given before the AIEE by Paul E. Gisiger[3]. He presented a table showing several representative underground plants, stated that they have almost become the rule rather than the exception for new developments in many parts of Europe. Several are now under construction, among them Harspranget plant, Sweden, 285,000 kw; Kilforsen, Sweden, 240,000 kw; to be finished in 1954; Santa Massenta, 284,000 kw and Providenza, 150,000 kw both in Italy; Bermano plant, Switzerland, 100,000 kw, about to be started.

Costs of Swedish Underground Plants

There is no general rule to determine whether or not a station should be underground, it was pointed out by Rusck and Westerberg in another paper[4], before the AIEE. In Sweden, wherever such plants have been built, it was the most economical solution of the problem and protection in time of war was only an

(Continued on page 116)

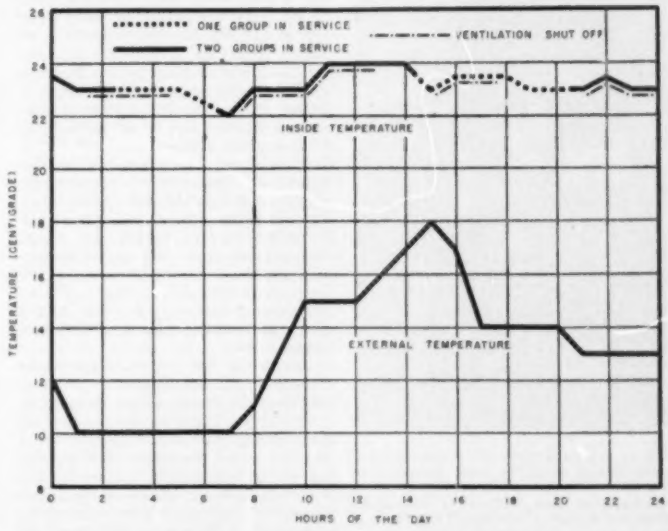

Fig. 3. Temperatures taken in power plant at Conconighe, Italy, May 27, 1948; Average relative humidity 56 per cent (Courtesy *Electric Light & Power*)

References

[1]Underground Hydroelectric Power Plants; Joseph D. Lamm, Board of Water Supply Engineer, New York City, paper before Annual Meeting, 1950, American Society of Civil Engineers.

[2]Hydroelectric Power Plants; C. Ritter; L'Energia Electrica (Italy).

[3]Underground Hydroelectric Plants; Paul E. Gisiger, Companhia Brasileria Administradora de Servicos Tecnicos, Sao Paulo, Brasil; paper No. 50-186 before American Institute of Electrical Engineers.

[4]Underground Hydroelectric Power Stations in Sweden; Ake Rusck and O. Westerberg, Swedish State Power Board; paper No. 50-149 before American Institute of Electrical Engineers.

Electric Generator Operates at 19,000 rpm

Unique application of Faraday's Disc generator, using liquid mercury jets as brushes, and running at 19,000 rpm, develops pulses of current of 50,000 amperes. Experimental machine developed at Case Institute of Technology for possible application in the design of betatrons and other particle accelerators used in nuclear research

ONE HUNDRED AND NINETEEN YEARS ago Michael Faraday rotated a copper disc edgewise between the poles of a horseshoe magnet and collected a continuous current from it by closing a circuit through two rubbing contacts, one on the periphery and the other on the shaft of the disc. This was the first electromagnetic generator, the forerunner of all our great turbine-generators today. It was a homopolar machine and since its field was provided by a permanent magnet, and since the current paths were not definitely controlled, it was extremely inefficient. A year later, H. Pixii developed and constructed the first heteropolar machine, and provided it with a wire armature winding.

Since then nearly all development has been along heteropolar lines, and while a few homopolar generators have been built for special purposes in recent years, the Faraday principle remained little more than a scientific curiosity.

During the last two years, however, an experimental generator of the same type has been built with some extremely interesting results. Developed by Robert I. Strough, Standard Oil Fellow and Instructor in the Department of Physics at Case Institute of Technology in Cleveland, this unique machine has brushes of liquid mercury instead of solid metal, coil *windings* that are not wound but cast out of solid copper, and derives its energy from a jet of compressed air which whirls a copper flywheel at 19,000 rpm.

The principle behind Strough's generator is that of Faraday's rotating disc generator but in this case the energy is so large and the speed so great that ordinary brushes could not handle the current without great loss. Hence, he solved the problem by using jets of mercury for brushes.

This *high current* generator is being studied as a possible energy storage system for an air-core betatron, and as a possible cloud chamber field supply in nuclear physics research. The rotor of the machine serves as a flywheel for energy storage and is driven up to speed, between current pulses, by means of compressed air jets acting on turbine buckets cut in the rotor. The present model employing a 5¾ in. diameter rotor weighing 11 lb will store up 64,000 joules at 30,000 rpm quite safely.

To obtain the negative resistance characteristic necessary for current build-up in the machine, it is essential that the brush resistance be kept very small. For this reason a brush system using mercury flowing between amalgamated surfaces was investigated. Static model tests indicated that such brushes may be operated at current densities of the order of 10,000 amperes per square centimeter with a contact resistance of the order of a few micro-ohms per square centimeter.

Fig. 1. A little flywheel with energy storage potentialities over 100 times greater than the electrical condenser bank behind him is exhibited by Case Institute of Technology physicist Robert I. Strough. The flywheel driven by compressed air is the heart of an experimental generator with amazing magnetic properties

Faraday discovering the principle of the electric generator in 1831

Later, dynamic tests indicated even more satisfying results. In these tests it was found that with the air supply available at the time, the maximum speed of the rotor is about 20,000 rpm. The critical speed of the rotor was found to be 15,000 rpm. At 19,000 rpm, a magnetic field of 4000 gauss is developed in the center of the disc and the current developed is about 50,000 amp. The generated voltage, however, was only 2.5 volts.

The machine operates with a short circuit, that is, no current is drawn off, the magnetic field being the important consideration. The current pulse lasts about 0.33 second.

The present model of the machine was developed only for study, not for *practical* use. Its purpose is quite different from that of conventional generators. The latter are designed for the steady, efficient production of power at ordinary levels, while the new machine is designed for the

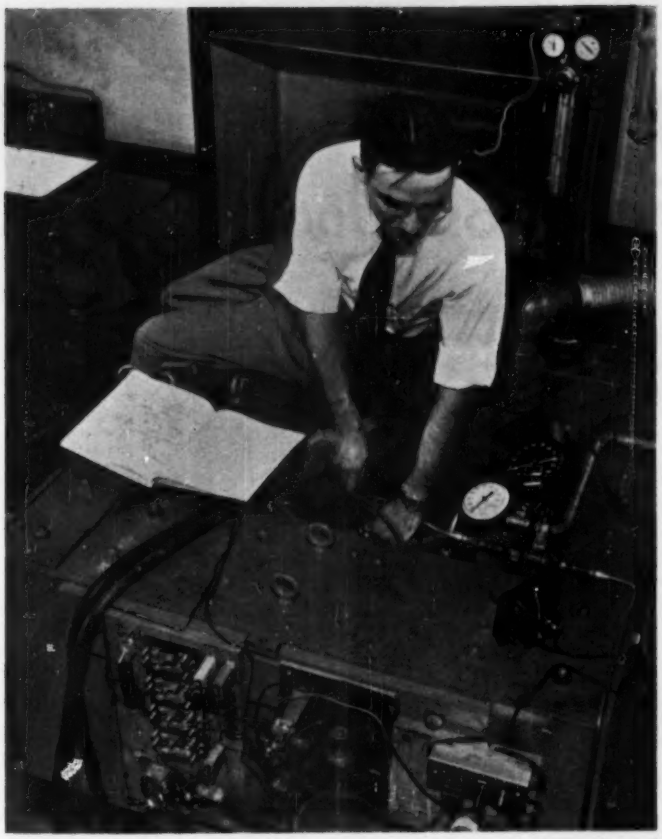

Fig. 2. Seated on a heavy steel protective barricade, Robert I. Strough, Case Institute of Technology physicist, adjusts his whirling-disc generator. The paradoxical machine has no iron in its magnetic circuit, uses "brushes" of liquid mercury, and is run by compressed air. At its heart is 5½ in. beryllium-copper flywheel which whirls at 17,000 revolutions per minute to develop a magnetic field over 6000 times as intense as that of the earth

production of short pulses of extremely high power. Its output is similar to the discharge of a high capacity condenser which has been charged at a comparatively slow rate. When such a condenser is short circuited all the stored energy is released in one high-current pulse. In the case of the Strough generator, it is the kinetic energy stored up in the rotating disc that is released. In this respect a comparison of the Strough generator with a condenser is rather remarkable, as shown by the photograph, Fig. 1. The little disc in Mr. Strough's hands has energy storage potentialities over 100 times greater than that of the large bank of condensers shown beside him.

The simple, solid disc rotor is ideal from an energy storage standpoint. Having no windings which might displace, it can be operated safely at very high speeds. The geometry of the disc generator is ideally suited to the use of its magnetic field because the field *is out where it is available*. The stator consists of but one turn, necessitated by the fact that the rotor is a disc.

The 5¾-in. disc of the generator is made of beryllium-copper, an alloy almost 98 per cent copper but as strong as tool steel. The maximum field obtainable with this type of machine is not limited by the saturation induction of iron to 20,000 gauss or so, but may theoretically reach much higher values since no iron is required for its operation. Elimination of the iron reduces the weight and brings the cost of a machine for producing a given volume of field below that for conventional generators and magnets. Of course, the generator is suited only to the production of fields of short duration. Energy is stored slowly and expended rapidly.

The only limiting factor in the Strough generator's capacity is the speed at which the disc will rotate before it flies apart. To prevent an accident if the disc should shatter, the experimental model is surrounded by a heavy barrier of timbers and steel, and special equipment has been provided to dispose of the poisonous mercury vapor developed. In sharp contrast to this huge protective barrier is the small portable air compressor which provides the motive power for driving the disc.

The generator was built as a laboratory experiment to test hypotheses developed by Strough and former Case student Richard Garwin in their Ph.D. thesis work under the direction of Professor E. F. Schrader of the Case Department of Physics. Strough sees a possible role for the machine as the magnetic core of a betatron or other type of particle accelerator. If such a machine could be worked out, it could save thousands of dollars worth of energy storing equipment, such as whole rooms full of condensers and tremendously costly magnets which are the bulk of most accelerators.

DETROIT EDISON TO BUILD NEW GENERATING STATION

DETAILED PLANS for a new 400,000 hp electric generating plant to be built on the St. Clair River front, midway between Marine City and St. Clair, have been announced by The Detroit Edison Co.

Paul W. Thompson, Edison vice-president in charge of engineering, said the cost of the new plant together with lines and other facilities for transmission and distribution, would run to "more than $35,000,000." Construction probably will begin early in December.

This major addition to Michigan's industrial and domestic power supply will be known as the St. Clair Plant.

The new plant will be equipped with two steam-turbine generators with "nameplate ratings" of 125,000 kw each. Actual capability of the plant will be in excess of 300,000 kw.

Completion of the project, scheduled for the end of 1953, will bring the Edison Company's total capacity to more than 2,600,000 hp. The program will not only add greatly to defense production power reserves in Michigan's key industrial area, but also will make extra power available in the state's Thumb District when and if needed.

The two new turbine generators already have been ordered, Thompson announced. One is being built by the General Electric Co. of Schenectady, the other by the Allis-Chalmers Manufacturing Co. of Milwaukee.

The machines are designed for high fuel economy. The boilers will be fired with pulverized coal, and stacks will be equipped with electrostatic dust collectors to assure clean operation.

Site of the new plant is a 423-acre tract flanking the St. Clair River about 50 miles northeast of downtown Detroit.

Cushing, Oklahoma, Diesel Plant Fuel Cost Under 2 Mills

Installation of new Dual-Fuel Engine and conversion of older engines to use of natural gas brings the total plant fuel cost well under two mills per kilowatt-hour. Electric rate schedules range from a maximum of 6 cents to a minimum of 1 per cent per kilowatt-hour. Conversion is cutting costs $20,000 a year

A NEW dual-fuel engine is producing power in the Cushing, Oklahoma, municipal plant for a total fuel cost well under 2 mills per kwh. The result is additional profit for a plant that already has earned more than a million dollars.

The achievements of dual-fuel equipment in this power station are particularly noteworthy because the plant is ideally located for the economical operation of oil-burning diesels. The oil refinery which supplies fuel to Cushing is just across the street from the plant and fuel is pumped directly from refinery storage tanks to plant storage tanks without any transportation costs. As a result, this plant currently pays less than 6 cents a gallon for a 36 API gas oil, and the margin for saving, even with cheap natural gas, is much smaller than in the average plant.

Yet, with the development of modern dual-fuel prime movers, it became evident to Cushing engineers that important savings could be effected by conversion to natural gas. First step was the conversion in November 1948, of the four McIntosh & Seymour diesels then in service, three 750-hp and one 1170-hp engines. Although the converted units required 21 per cent pilot oil, the total cost of fuel per kwh was cut from an average of 5.23 mills in the fiscal year ending June 30, 1948, to an average of 3.96 mills the following year. This figure has been improved and peak performance of these units gives a cost of only 2.3 mills.

When the expanding load made further plant expansion imperative, it was natural for Cushing officials to seek an efficient dual-fuel engine capable of affording a maximum return for every dollar spent on fuel. Also, the city's engineers wanted a slow-speed, heavy-duty prime mover that could be depended on for unfailing service over a long period of years. Their choice was a four-cycle, six-cylinder Fulton engine of 17½-in. bore and 24½-in. stroke, rated at 1420-hp at a slow 277 rpm. This supercharged engine is designed to run on natural gas with just 7 per cent pilot oil. It can, of course, also operate as a full diesel.

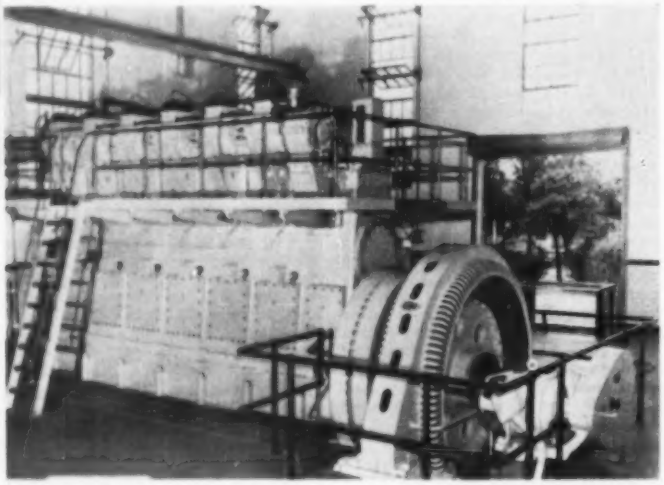

Fig. 1. The new Fulton engine drives an Electric Machinery generator with chain-driven exciter. Also visible in this picture are the Woodward governor and the Electric Auto-Lite thermometer

The engine was installed in June, 1949, and a thorough field test was conducted August 22nd by the engineering firm of V.V. Long & Co. The accompanying table gives a detailed report on that test, including load, consumption of fuel oil and natural gas, cooling water pressures and temperatures, exhaust temperatures, lube oil pressures and temperatures, piston cooling oil temperatures and other significant performance data. The percentage of total Btu requirements supplied by the pilot oil varied with the load from an exceptionally lean 5.1 per cent to a moderate 8.5 per cent. Thermal efficiency was good, with Btu consumption always lower than the guarantees. Here is the comparison for dual-fuel operations:

Load	Btu Per Bhp Hr.	
	Guarantee	Test Performance
½	7900	6848
¾	7200	6356
Full	6800	6095

In actual operation, this efficiency level has meant a total fuel cost close to 1.75 mills per kwh. As a result, the new engine is kept in continuous operation except for necessary servicing. When the writer visited the plant, the valley load was about 600 kw, which would have provided a better load factor for the 1170-hp unit, but the superior econ-

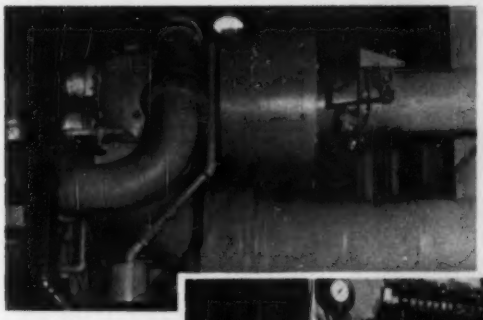

Fig. 2. (Left) For dual-fuel operation intake air is controlled by the governor by means of air operated valves. This shows the control mechanism, the Air Maze air filter and silencer and the Elliott-Buchi turbocharger

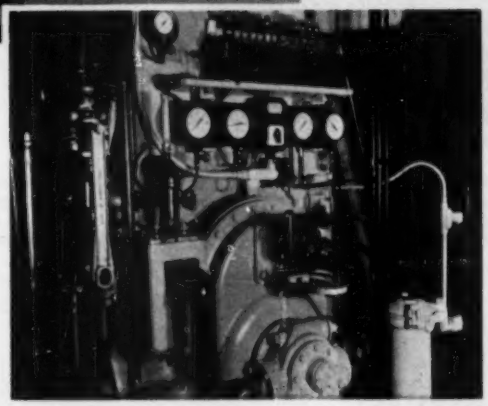

Fig. 3. (Right) Included in this close-up are the Manzel cylinder lubricators, the Brown exhaust pyrometer, the Cuno lube filter and the Nugent fuel filter

Principal Equipment Serving New Engine, Cushing, Okla., Municipal Power Plant

Engine: Four-cycle, six-cylinder, 17½ X 24½-in., 1,420-hp, 277 rpm, supercharged dual-fuel engine. Fulton Iron Works.

Generator: 1250 kva, 1000 kw, 2400 v, 3-phase, 60 cycle synchronous generator. Electric Machinery Co.

Turbocharger: Elliott-Buchi. The Elliott Co.

Governor: Woodward Governor Co.

Gas Regulator: Emco. Pittsburgh Equitable Meter Co.

Fuel meters: Pittsburgh Equitable Meter Co.

Engine air controls: Westinghouse Air Brake Co.

Lubricating oil: Rubilene Heavy. Sinclair Refining Co.

Lube filters: Hilco Hyflow. The Hilliard Corp. Cuno Engineering Co.

Lube reclaimer: The Hilliard Corp.

Turbo lube filter: Wm. W. Nugent Co.

Cylinder lubricators: Manzel Brothers.

Lube cooler: Graham Mfg. Co.

Auxiliary lube pump: Tuthill Pump Co.

Fuel oil filter: Wm. Nugent & Co.

Cooling water pumps: Fairbanks, Morse & Co.

Cooling towers: Marley Co. United.

Starting air compressor: Worthington Pump & Mach. Corp.

Intake air filter and silencer: Air Maze Corp.

Piston rings: American Hammered. The Koppers Co.

Exhaust pyrometer: Brown Instrument Co.

Thermometers: Electric Auto-Lite Co.

omy of the new unit made it desirable to run the 1420-hp engine 24 hrs a day with loads varying from 60 to 80 per cent.

It is expected that the new engine will produce more than half the plant's total annual energy output of 10,000,000 kwh. In all, the switch from straight diesel to dual-fuel has meant a fuel saving of about $20,000.00 a year.

Design of the Fulton's fuel system provides for accurate control of both gas and intake air to insure proper balance and good combustion at all loads. The gas reaches the plant at 20 psi, is reduced by a regulator to 12 psi and is carried to the cylinders by a header. At each cylinder there is a gas admission valve activated by a rocker arm from a cam shaft. Governor linkage turns a shaft which controls the effective opening of the valves and thereby the amount of gas admitted to the cylinders.

Intake air passed first through a governor-controlled admission valve, then through a filter and silencer to the exhaust-driven turbo-charger. To achieve swift, sensitive control, the air valve is actuated by a compressed air system. A ¼-in. line from the starting air bottle at 200 psi carries air through a regulator where pressure is reduced to 65 psi, then to a governor-controlled actuating valve which operates the air intake valve. Reaction to changes in load is almost instantaneous.

If gas pressure fails, lube pressure moves a piston altering governor linkage and automatically switches the engine to full dependence on diesel oil.

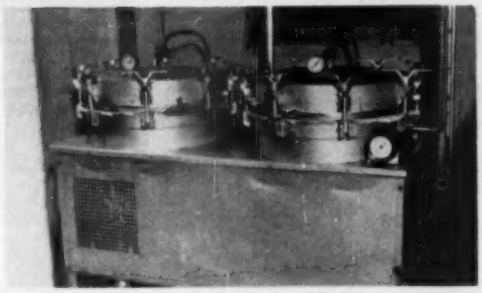

Fig. 4. In addition to continuous filtration, lubricating oil is put through this Hilco oil reclaimer

For normal dual-fuel operation, pilot oil is regulated at about 7 per cent of full-load fuel requirements. Fuel oil is pumped through waste-packed filters to storage, then to elevated day tanks in the engine room and finally by gravity through bag-type filters to the engines.

Handling of lubricating oil has been notably successful in this plant and seems destined for even better records. The horsepower-hours per gallon of lubricating oil consumed in the year ending June 30, 1949 was 6057, but the plant reports that the new engine is running 8500 hp hr per gal of lube consumed.

Needless to say, all lube is reclaimed and none is discarded. Oil is pumped continuously from engine sumps through a fuller's earth filter and back to the sumps. The filter serves all the engines and is switched every 8 hours. In addition, there is an oil reclaimer which combines fuller's earth filtration with an electronic vaporizer to eliminate water and fuel dilution. This unit, too, serves all the engines and usually is switched at 24-hour intervals. Oil samples are sent in for laboratory analysis every six months and the reports always show the oil as good as new with no acid, sedimentation or residue. Consequently no oil change has been made in 12 years. Further evidence of successful lubrication is the absence of stuck rings and the small cylinder wear.

All bearings of the new engine are lubricated by a pressure system which also supplies oil to cool the pistons. Included in the system are an engine-driven pump and a shell-and-tube oil cooler. Cylinders are supplied with oil by force-feed lubricators. The only new oil added goes into these lubricators; none ever is added directly to the crankcase supply.

Fig. 5. Exterior view of the Cushing Municipal Power Plant

Duplicate equipment insures adequate cooling for the engines. All the prime movers are tied in to dual cooling water headers, either of which can handle the entire plant. Water is circulated through the engine jackets and through the coils of two induced-draft cooling towers by five motor-driven centrifugal pumps while an equal number of pumps handle raw water for the towers. Four new 800 gpm centrifugal pumps were installed with the new engine. City water is used for makeup and receives further treatment before introduction into the jacket supply.

The plant has been enormously profitable despite rate schedules which range from a maximum of 6 cents to a minimum of 1 cent per kwh. This compares with a maximum rate of 11 cents per kwh, which prevailed when first action was taken to develop a municipal plant.

Official reports for the fiscal year ending June 30, 1949, show an income of $285,872.92 and expenses (including administration, generation, distribution and fixed charges) of $157,894.31, leaving a net gain of $127,978.61. The balance sheet shows a total surplus of $1,282,311.74, accumulated since the plant was started in 1936.

Impressive as these figures are, they gain by translation into community benefits. This city of 10,000 population has unusual cultural and recreational facilities. There is a $150,000.00 swimming pool and another is planned. There is one concrete stadium for baseball and another for football. There are a large modern library, air conditioned municipal buildings, a new fire house. To top it all, the city is tax-free.

With its new engine producing power for a total fuel cost of just 1.75 mills, this fast-growing prosperous community can look forward to greater profits and further benefits.

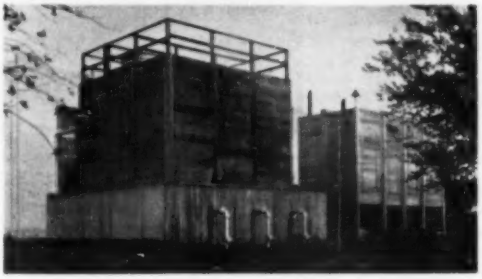

Fig. 6. Cooling water is circulated through these induced draft cooling towers, one a United, the other a Marley

Field test of 1420-hp Dual-fuel engine by V. V. Long & Co.

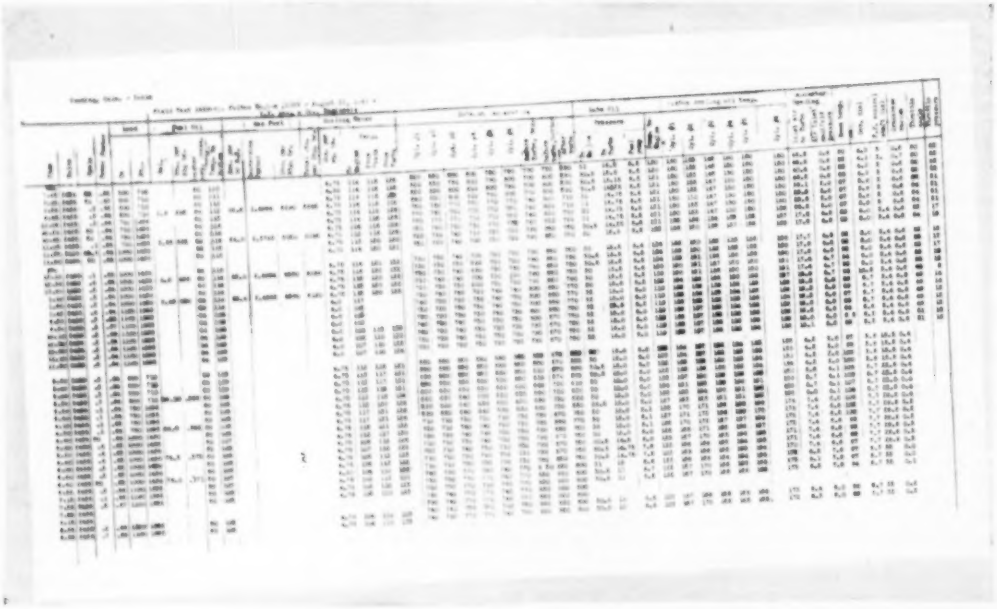

Fig. 1. Exterior view of the new Measurements Laboratory of the General Electric Co. Meter and Instrument Divisions at Lynn, Mass. The 5-story brick, steel and concrete building houses complete facilities for applied research, product development and design in the field of measurements. The building was designed by J. Gordon Turnbull Inc., of St. Louis and built by the Thompson-Starrett Co. of New York City

G-E's New Measurements Laboratory at Lynn

ON OCTOBER 30, the General Electric Co. officially opened its new measurements laboratory, believed to be the most modern and best equipped of its kind in the world. It is located at Lynn, Massachusetts.

As pointed out by H. E. Strang, divisions manager, this laboratory represents the ultimate in facilities devoted exclusively to the development of new measuring devices, and the critical analysis and improvement of designs already on the production lines. Two major objectives guided the company in designing and equipping the new laboratory: (1) to provide the best possible tools for the staff of more than 300 measurement specialists; and (2) to remove all physical barriers from coordination and integration of their work.

These goals were achieved by making the latest specialized laboratory apparatus and all required electrical and mechanical services readily accessible to all specialists, and by allotting them ample space in light, comfortable, semi-private workrooms. Unlimited mechanical and electrical services have been made available to all work areas through a complete system of pipes and bus ducts suspended from the corridor ceilings. Mechanical services include hot and cold water, vacuum, process steam, nitrogen, oxygen, high pressure air, city gas, and to two areas where it is used in quantity, low pressure air. Electrical power for general use is served to rooms on each side of five floors from a modern power distribution center in the basement. This service offers direct current at 125 volts and alternating current at 240 volts, 3-phase, and 208/120 volts single phase. Special power services are available from storage batteries, banks of motor-generator sets and specially designed electronic power supplies for all the range of measurement applications from microvolts to kilovolts and from microamps to kiloamps.

To keep a constant check on the calibration of testing equipment, a set of primary standards, equivalent to those at the Bureau of Standards in Washington, is maintained at the laboratory. The applicable standards include time, temperature, resistance, and volts. The standard cells used to maintain the value of the volt as well as the standard ohmic resistances, are contained in a heavily insulated oil bath held at constant temperatuare.

Fig. 2. (Below) Unlimited mechanical and electrical services are available to engineers and technicians. This view of one of the lab's work areas shows the conveniently located taps for hot and cold water, vacuum, process steam, nitrogen, oxygen, hydrogen, high-pressure air and city gas

Fig. 3. (Above) Showing the bus ducts and some of the piping services in the corridors. Here a technician switches an electrical connection to the instrument testing areas

Static Magnetic Regulators in

During the past five years a change of fundamental significance has come into the field of exciter practice for large electric generators. This is the change from the use of conventional excitation systems to those using the static-magnetic type of regulators. The static-magnetic regulator is a relatively new device under the sun, yet its advantages are so obvious that in a few short years they have become widely accepted in the industry. Last March, it may be recalled we presented an article dealing with the maintenance of these regulators. Now, we present this article telling what they are and exactly how they operate by the same author

STATIC-MAGNETIC regulators were developed to meet the need for regulating equipment which would give maximum reliability in service, and which would require minimum maintenance throughout its useful life. These characteristics are inherent in static magnetic regulators, and are present to an appreciably greater degree than in conventional electromechanical or electronic regulators. Therefore, it is logical that this modern type of regulating equipment has gained initial importance in commercial use in the power generation field where reliability and maintenance carry unusual significance. Here, static-magnetic regulators first appeared as voltage regulators for large synchronous machines, and in spite of the fact they became generally available to the industry only a little over 5 yrs. ago, they have already been widely accepted for new central-station voltage-regulator applications. A big proportion of the larger generators and synchronous condensers purchased during the post-war period have been provided with static-magnetic voltage regulators, and it is probable that most voltage regulators sold today for use with large synchronous machines are of this new type.

Static-magnetic regulators generally employ transformers, conventional reactors, and saturable reactors as the chief elements from whose characteristics a regulating function is obtained. These elements are physically static; that is, they function without movement. Furthermore, they are magnetic devices in that they employ the characteristics of magnetic materials. The name "static-magnetic" has been derived from these two features, and serves to clearly distinguish this type from the other conventional types of regulating equipment. Other components commonly used in static-magnetic regulators are resistors, metallic rectifiers, and capacitors, all of which are also static devices. Adjustment in service is usually accomplished with semistatic components such as rheostats, variable transformers, apd tap switches.

Amplidynes, or special direct-current generators with unusually great amplification factors and high speeds of response, are frequently used with static-magnetic regulators — particularly in applications involving large machines. This association has become so common, that where amplidynes are used with this type of regulator they are usually considered as a part of the regulator and are often supplied in this manner. In such cases, the regulator and amplidyne are called a static-magnetic amplidyne regulator.

The major functions of a static-magnetic regulator are the same as those which must be provided by any other type of regulator. The first function consists of the detection of an error or change in the regulated quantity. Since the error detection circuits must operate at exceedingly low power levels, due to practical design factors such as size, power consumption, cost, and accuracy, the error signal provided by the error-detection circuits must be amplified to make it useful with ordinary rotating machines. Therefore, the second function consists of the amplification of an error signal. Furthermore, because the responsibility for operation of the complete regulating system without hunting or objectionable oscillation is assigned to the regulator, its third function is to provide system stability. This is usually accomplished

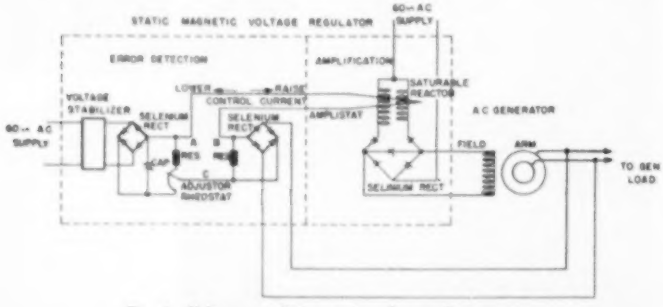

Fig. 1. Voltage regulating system for small generators

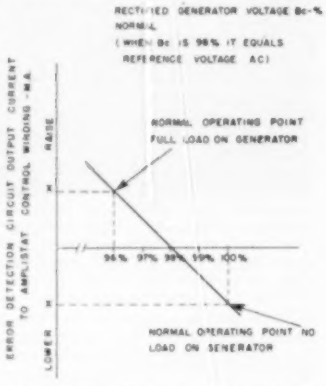
RECTIFIED GENERATOR VOLTAGE Ec-% NORMAL
(WHEN Ec IS 98% IT EQUALS REFERENCE VOLTAGE AC)
ERROR DETECTION CIRCUIT OUTPUT CURRENT TO AMPLISTAT CONTROL WINDING - MA
RAISE
LOWER
NORMAL OPERATING POINT FULL LOAD ON GENERATOR
96% 97% 98% 99% 100%
NORMAL OPERATING POINT NO LOAD ON GENERATOR

Fig. 2. Error detection circuit characteristic

the Power Generation Field

By W. A. HUNTER
Control Division, General Electric Company
Schenectady, N. Y.

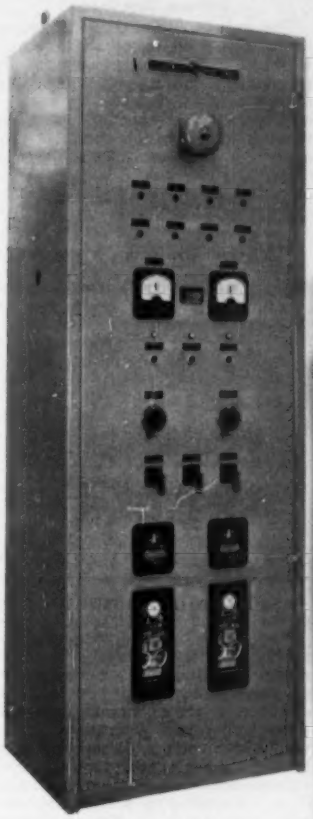

Fig. 3-A. Typical load regulator for a turbine generator

with separate stabilizing circuits, but in some cases may be achieved by appropriate design of the error detection and amplifying circuits. Recognition of the three basic functions of error detection, amplification, and stabilizing permits ready functional classification of the various circuits of a static-magnetic regulator. Such functional classification allows individual consideration of circuits associated with each of the basic functions, thereby greatly facilitating comprehension of the operation of the complete regulator. This technique is employed here in describing several typical regulating systems which include static-magnetic regulators.

Classification of Circuits

Circuits are classified according to principal function, and where a circuit has more than one function, only the principal function is mentioned. This procedure is used to promote clarity and simplicity, but it must be remembered that the circuits of static-magnetic regulators frequently have more than one function. This is particularly true for the stabilizing function which is often influenced by all of the regulator circuits.

The term regulating system is used to describe all of the elements associated with the regulating function. These include not only the regulator, but all of the devices and machines which it controls to accomplish the desired result. The term regulator is used to describe that portion of the system which is not required for manual or non-automatic control of the major elements or machines, but which has been provided to secure automatic control of these elements. Such use of the term regulator is somewhat arbitrary since this rather loose definition cannot always be applied in practice. But the term has gained general usage on this basis over the years during which regulating systems have been employed. Its practical value lies mainly in serving as a convenient means for identifying the portion of the regulating system which is conceived and largely designed by the regulating-system design engineer, and supplied by the regulator manufacturer.

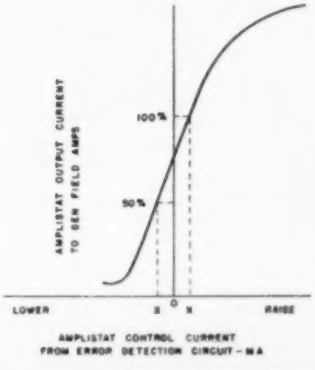

Fig. 3. Amplistat characteristic

The first static-magnetic regulator which will be considered is not typical of equipment used in the power generation field, but its design makes it particularly suitable for describing the important features of this type of regulator. The regulator is used to automatically control the terminal voltage of small, special-frequency, alternating-current generators. A simplified diagram of the complete voltage-regulating system is shown in Fig. 1. The regulated quantity is, of course, the terminal voltage of the generator. This machine is excited by an amplistat which uses a separate a-c supply as a source of power. An amplistat, or magnetic amplifier, consists of a special type of saturable reactor and a metallic rectifier, and is used here to convert a-c power to d-c power. Its d-c output is varied by changing the current in a control winding on the saturable reactor; direct current passing through this control winding in one direction will increase the direct current supplied to the generator field, and direct current passing through the control winding in the opposite direction will decrease the direct current supplied to the generator field. The control winding receives direct current from a simple error-detection circuit in which the generator terminal voltage is rectified and compared with an essentially constant d-c voltage secured by rectifying the output of a standard voltage stabilizer. The regulator circuits are classified in accordance with the previously described basic functions of error detection and simplification. The regulator

fulfills the stabilizing functional requirement but does not employ separate circuits for this purpose since it was possible to design the circuits which accomplish the first two functions in a manner that produces stable system operation.

Voltage Stabilizer

The voltage stabilizer is a device commonly used to obtain a small quantity of alternating current at an essentially constant voltage in spite of appreciable changes in power-supply voltage. By using a selenium rectifier to rectify the output of this device, a reasonably constant d-c

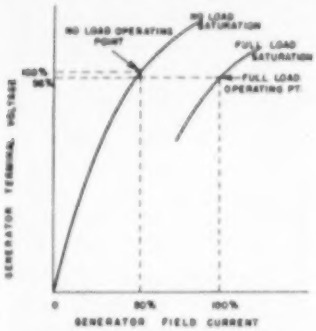

Fig. 4. Generator characteristic

voltage is secured. A filter capacitor is employed to minimize ripple.

The d-c voltage appears across points A and C, and may be adjusted to the desired value by altering the position of the adjuster rheostat. Voltage AC is called the reference voltage, and its magnitude establishes the generator voltage under any given operating condition. A d-c voltage, directly proportional to the generator terminal voltage, appears across points B and C; it is supplied by a selenium rectifier connected to the generator terminals. The polarity of voltage BC opposes that of Voltage AC, and the voltage appearing across points A and B is the difference between voltages AC and BC. The current supplied by the error-detection circuit to the amplification circuit is directly proportional to voltage AB; this current will be in the "raise" direction when voltage BC is less than AC, and will be in the "lower" direction when BC is greater than AC. This characteristic is illustrated in Fig. 2. Normal operating points with the generator at no load and at full load are also shown.

The amplification function of the regulator is assigned to the amplistat and the characteristic of this device is shown in Fig. 3. When there is no current in the control winding, a definite value of direct current will be delivered by the amplistat to the generator field. This current may be increased by passing direct current through the control winding in the raise direction, and may be decreased by passing current in the lower direction. Consequently, the current supplied by the amplistat will depend upon the current supplied by the error detection circuit. Normal operating points with the generator at no load and at full load are indicated.

The purpose of the complete regulating system is to maintain the generator terminal voltage nearly constant despite changes in generator load. The generator characteristic is shown in Fig. 4 which illustrates the dependence of the generator voltage upon both the field current and the generator load. Therefore, the regulator must automatically vary the field current when the generator load is altered. With the generator operating at 100 per cent voltage and no load, the required field current is only 50 per cent of rated. Fig. 3 indicates that the amplistat requires lower control current to secure this field current. As shown in Fig. 2, lower control current will be produced when the rectified generator voltage BC is slightly greater than the reference voltage AC. However, when the generator is operated at full load, about 100 per cent field current is required to secure approximately rated terminal voltage. To meet this condition, the amplistat control current must be in the raise direction, and the rectified generator voltage must be less than the reference voltage, or 96 per cent of the no load value. Therefore, as the generator load is varied between no-load and full load, the generator terminal voltage will be held between 100 per cent and 96 per cent respectively of the no load value. In other words, the no load to full load voltage regulation will be 4 per cent of the no load voltage.

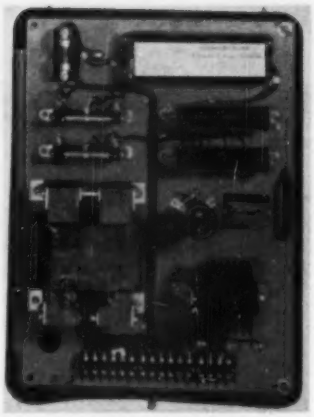

Fig. 5. Static-magnetic regulator for small high frequency generator

Regulator Design

The regulator design is relatively simple. The voltage regulation secured with it is entirely adequate for the application for which it was designed, and where desired the regulation can be greatly bettered by the addition of a second magnetic amplifier connected between the existing amplifier and the error-

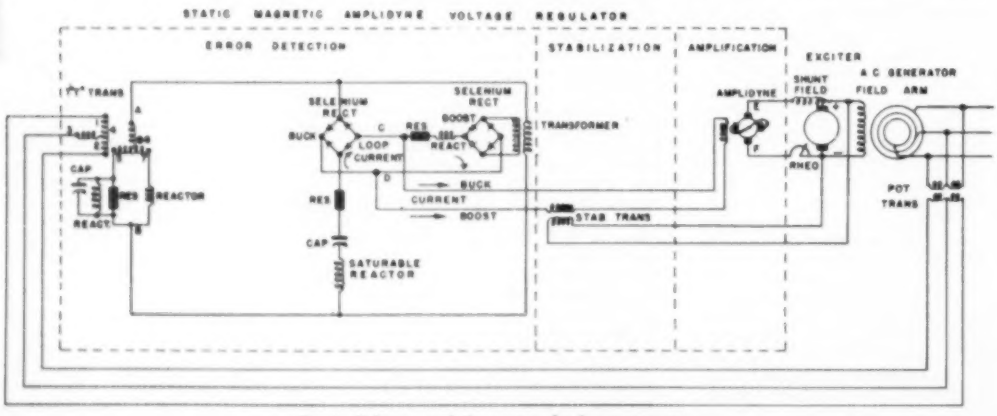

Fig. 6. Voltage regulating system for large generators

detection circuit. Furthermore, the regulator responds rapidly to changes in generator voltage, which is an essential characteristic. The absence of moving parts and the use of components with inherently long life make it unusually reliable, and reduce regular maintenance to little more than inspection at infrequent intervals. One of its outstanding features is the elimination of the conventional rotating exciter for the generator, thereby completely dispensing with maintenance activities commonly connected with this type of machine. Use of standard 60-cycle power makes the regulator essentially independent of the generator frequency, and readily applicable to a wide range of generator sizes and ratings.

A typical regulator is shown in Fig. 5 which illustrates the compactness, ruggedness, and general accessibility of components which characterize this type of equipment. Although the regulator was developed for high-frequency generators up to roughly 150 kw used in induction-heating processes, it may be readily applied to many a-c gen-

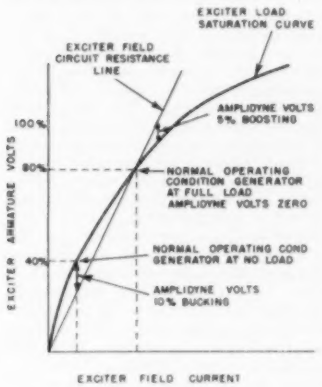

Fig. 7. Exciter characteristic

erators used in various fields. Adaption for use with d-c generators is quite simple, making it suitable for numerous applications such as battery charging and general purpose power supply.

Static-Magnetic Regulator for Large Generators

The static-magnetic regulator which is considered next is being widely used in the power generation field to automatically control the terminal voltage of large generators, synchronous condensers, and frequency changers. A simplified diagram of the voltage-regulating system is shown in Fig. 6; individual circuits have been identified according to principal function. The generator is excited by a conventional rotating main exciter which is a self-excited shunt machine equipped with the usual shunt field rheostat. Connected in series with the exciter field is an amplidyne which is capable of introducing a voltage in the field circuit in either direction. When the amplidyne voltage is zero, the exciter armature voltage is determined by the setting of the field rheostat. When the amplidyne voltage EF is positive at F, it adds to or boosts the exciter voltage and increases the exciter field current to raise the exciter armature voltage. When the amplidyne voltage EF is positive at E, it opposes or bucks the exciter voltage and decreases it by decreasing the exciter field current. Consequently, the amplidyne may be used to vary the exciter voltage without changing the position of the exciter field rheostat.

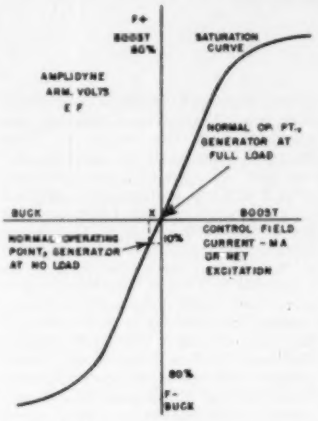

Fig. 8. Amplidyne characteristic

This is illustrated in Fig. 7. The exciter field rheostat is adjusted to give 80 per cent of rated exciter voltage when the amplidyne voltage is zero. This value of exciter voltage is assumed to be correct to cause the generator voltage to be at about the rated value when the generator is carrying full load. To secure 40 per cent of rated exciter voltage, the amplidyne must provide about 10 per cent of its rated voltage in the bucking direction; to obtain rated exciter voltage, the amplidyne must produce roughly 5 per cent of rated voltage in the boosting direction. It is assumed that 40 per cent of rated exciter voltage will give rated generator voltage at no load. The generator characteristic is similar to that shown in Fig. 4.

Amplidyne

The amplidyne is equipped with a separately exciter control field; the magnitude and direction of the amplidyne voltage is determined by the magnitude and direction of the current in this field. This is shown in Fig. 8 where the amplidyne voltages and field currents corresponding to generator no-load and full-load conditions are indicated. The amplification function of the regulator is accomplished by the amplidyne which greatly amplifies the small amount of power delivered to its control field by the error detection portion of the regulator.

The characteristic of the error-detection circuits is shown in Fig. 9. When the generator voltage increases above the rated value, the buck current supplied to the amplidyne will be increased, thereby increasing the amplidyne buck voltage, and decreasing the exciter voltage to retard the increase in the generator voltage. If the generator voltage should decrease, as might be caused by an increase in generator load, the buck current to the amplidyne will be decreased, so that the amplidyne buck voltage will be lowered. This will allow an increase in exciter voltage which will oppose the decrease in generator voltage. An appreciable decrease in generator voltage will cause reversal of the error-detection-circuit output current, and will produce boost amplidyne voltage. The normal no-load and full-load operating points indicated in Figs. 8 and 9 show that when the generator voltage is at the rated value, the error-detection circuits will provide the bucking control-field current required to produce the 10 per cent bucking amplidyne voltage which will satisfy the no-load operating condition, and that when the generator voltage is 99 per cent of rated value, the control field current and amplidyne voltage are zero, which meets the full-load operating requirement. Therefore, the no-load to full-load voltage regulation is 1 per cent. It is evident that only a small part of the rated amplidyne voltage is required under normal operating conditions. The maximum voltage requirement shown in this example is only 10 per cent of rated value, and for most applications does not exceed 20 per cent of rated value. As a result, considerable excess voltage is available for use in rapidly increasing or decreasing the exciter voltage under conditions which require large and sudden changes in generator excitation.

The "T" transformer and the resistor and reactor connected across its secondary winding 5-7 provide a single-phase voltage at points A and B which is proportional to the average of the three-phase voltages of the generator. The capacitor and reactor connected across points 5 and B operate in resonance at rated generator frequency, and act to vary voltage AB in proportion to frequency to offset the influence of frequency changes upon following circuits. Voltage AB is impressed across two parallel circuits which supply direct current to a loop comprised of two rectifiers, respectively identified as buck and boost rectifiers, and a resistor and reactor. Current normally flows around the

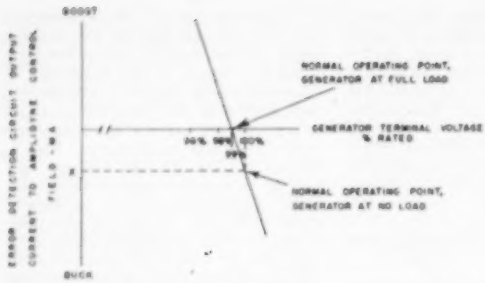
BOOST
BUCK
ERROR DETECTION CIRCUIT OUTPUT CURRENT TO AMPLIDYNE CONTROL FIELD - MA
NORMAL OPERATING POINT, GENERATOR AT FULL LOAD
GENERATOR TERMINAL VOLTAGE % RATED
NORMAL OPERATING POINT, GENERATOR AT NO LOAD

Fig. 9. Error detection circuit characteristic

loop in the direction indicated by the arrows. When the generator voltage increases, voltage AB will increases proportionately, the saturation of the saturable reactor will increase thereby lowering its reactance, and the current delivered by the buck rectifier will rise sharply. This will raise the voltage at point C over that at D so that buck current is supplied to the amplidyne field, which will cause the system to oppose the increase in generator voltage. If the generator voltage should decrease appreciably, the saturable reactor will desaturate, thereby decreasing the buck rectifier current and lowering the voltage at C below that at D. Boost current will be supplied to the amplidyne and the system will act to retard the increase in generator voltage.

The stabilizing function is represented by a stabilizing transformer. This device introduces a voltage in series with the amplidyne field whenever the exciter voltage is changing. The net effect is to retard fluctuations in exciter voltage, to prevent hunting or objectionable system oscillation.

A photograph of the error-detection portion of a typical regulator is shown in Fig. 10. It is arranged for installation in switchgear enclosures, or for assembly as part of a completely integrated, fully enclosed, factory assembled unit which includes all apparatus directly associated with the regulator. This type of equipment is suitable for use with all sizes of large synchronous machines, and has been applied to units with ratings between 5000 kw and 150,000 kw. Such regulators have found application in all parts of the United States as well as in a number of foreign countries. Units in service have adequately demonstrated their ability to provide outstanding reliability and performance. Maintenance has been almost nonexistent and has been generally confined to the amplidyne which requires the attention normally given to small d-c machines. This maintenance is readily accomplished since the regulator may be removed from service by simply switching the amplidyne out of the exciter field circuit, which is conveniently done without affecting the generator operating conditions in any way. This feature, combined with the elimination of the need for a pilot exciter, has contributed greatly to the broad acceptance of the regulator in the power-generation field.

Load Regulation

Static-magnetic regulators have also been applied to large generators as load regulators. The system shown in Fig. 11 is typical of such applications. It is designed to vary the power output of an industrial plant turbine driven generator in a manner which will maintain the power supplied to the plant by a utility at a relaltively constant value. This is accomplished by causing the plant generator to handle all changes in plant load. The regulated quantity is obviously the power supplied to the plant over the utility tie line. When the plant load increases, the plant generator and tie line will tend to share the increase. However, any increase in tie-line power will cause the regulating system to increase the generator load until it has accepted all of the increase in plant load and returned the tie line power to the desired value. In the same manner, a decrease in plant load will result in a corresponding decrease in generator load.

Changes in generator load are effected by adjusting the hydraulic mechanism which controls the turbine inlet valves. A d-c motor is used for this purpose, and in some cases its function is identical to that of the usual turbine governor synchronizing motor. Operation of the motor in one direction will cause the turbine generator load to increase, and operation in the opposite direction will result in a decrease in load. Reversible armature power for the motor supplied by an amplidyne permits motor operation in either direction. The amplidyne has two identical control fields which are excited by the error detection circuit. These fields are connected in opposition, so that when equal currents are passed through them, the effect of one field cancels that of the other, and the net excitation of the amplidyne is zero. If the current through the field marked "raise" in Fig. 11 is greater than the current through the "lower" field, the net excitation of the amplidyne will be in the "raise" direction. This will produce an amplidyne voltage proportional to the net excitation and with a polarity which will cause the motor to operate in a direction to reduce the turbine generator load and raise the tie line load. The opposite effect will result if the "lower" field current is greater than the "raise" field current. The amplidyne characteristic is similar to that shown in Fig. 8; the terms buck and boost should be substituted with "lower" and "raise" respectively.

The error detection circuit characteristic is shown in Fig. 12. This circuit will provide zero amplidyne excitation when the tie line load is correct, by supplying equal voltages, and therefore equal currents to the two identical control fields. Under this condition, the turbine generator load will not be affected since the motor which controls the turbine inlet valve mechanism will be at rest. An increase in tie line load, such as produced by an increase in plant load, will cause the error-detection circuit to provide

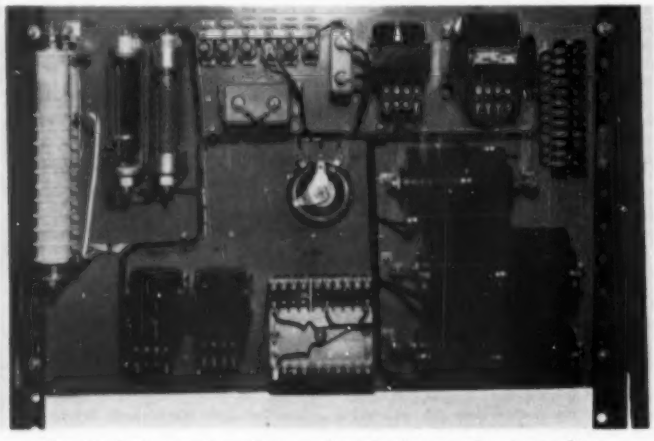

Fig. 10. Static-magnetic voltage regulator for large synchronous machines

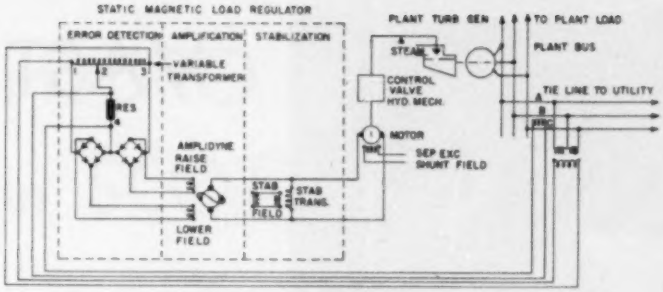

Fig. 11. Load regulating system

net amplidyne excitation in the lower direction which is proportional to the deviation of the tie line load from the desired value. This will result in an increase in generator load at a rate proportional to the tie-line load deviation until the line load has been reduced to the desired value, at which point the error-detection circuit will reduce the amplidyne excitation to zero, and the motor will cease changing the generator load.

The error-detection circuit will not respond to reactive load variations, but will respond only to changes in tie line kw load if the tie-line voltage remains essentially constant, which can usually be accomplished with a voltage regulator. Circuit relations are shown in Fig. 13. The voltage across the variable transformer is represented by vector 1-3 which is in phase with tie line phase B voltage, and the voltage across the resistor is represented by vector 2-4 which is in phase with and proportional to tie line phase B current. Length X between point 2 and the midpoint of vector 1-3 is proportional to the displacement of the variable-transformer slider from the midpoint of the transformer winding. It determines the tie-line load which the regulator is adjusted to maintain. The regulator operates to hold the in-phase or kw component of vector 2-4 equal to X. Under this condition the voltage applied to the raise field 3-4 will equal the voltage applied to the lower field 1-4 so the field currents will be equal and the amplidyne net excitation will be zero. An increase in tie line kw load will result in an increase in the in-phase component of vector 2-4 which will cause the lower field voltage to increase and the raise field voltage to decrease. This effect is shown in dotted lines and results in an increase in generator load to reduce the tie line kw load to the desired value.

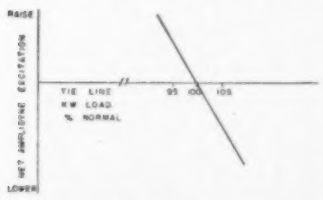

Fig. 12. Error detection circuit characteristic

Use of Load Regulators

Static-magnetic regulating equipment of this type has been applied in industrial plants to restrain rapid and large fluctuations of plant load from causing undesirable disturbances in the power systems of utilities.

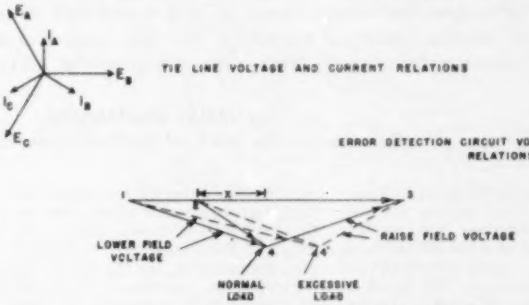

Fig. 13. Error detection circuit relations

It has also been employed by a utility to cause one generating station to follow the violent load swings of an adjacent rolling mill in order to minimize disturbances to the rest of the utility's power system. Industrial application has also been made to control the use of demand power, making it possible for an industrial concern with a widely varying plant load to purchase power at attractive demand rates. A typical equipment is shown in Fig. 3A. It includes the regulator and associated protective and control equipment for manual as well as automatic operation. Regulators of this kind have been used to control the loads of generators with ratings between about 5000 kw and 40,000 kw.

The three static-magnetic regulators described are quite different in design and illustrate well many of the features of this type of regulating equipment. They demonstrate the basic simplicity of design and operation which characterizes static-magnetic regulators. This simplicity is important not only to engineers responsible for the selection and proper application of regulating equipment, and who must therefore readily comprehend the manner in which it functions and the results it can produce, but is also vital to operating and maintenance personnel whose understanding of its operation contributes greatly to its efficient use. Simplicity of design also reduces the possibility of failure in service, and makes installation and initial as well as subsequent adjustment less difficult, and consequently less costly. Again, the examples discussed serve to indicate the flexibility with which static-magnetic regulators may be designed to meet the particular requirements of a wide range of regulating-system applications. Furthermore, the importance of the magnetic amplifier and the amplidyne as regulator components is shown. The high amplification accompanied by rapid response of these two devices, coupled with the completely static feature of the magnetic amplifier and the readily reversible output of the amplidyne, have made these devices almost indispensable, and have contributed greatly to the rapidly growing importance of static-magnetic regulators.

Static-magnetic regulators are now being used to regulate synchronous machine voltage, generator load, generator current, synchronous motor reactive load, and synchronous motor power factor. They have been employed with a-c and d-c machines, and applications range from some of the smallest to some of the largest machines built. These regulators are appearing in many areas including railway, industrial, central station, marine and aircraft, and their use in all kinds of applications is increasing steadily. The outstanding performance which they provide, the great reliability they offer, and the ease with which they may be maintained make them an invaluable regulating tool, and have already made them the leading type of regulator for large synchronous machines used in the power-generation field.

VAST

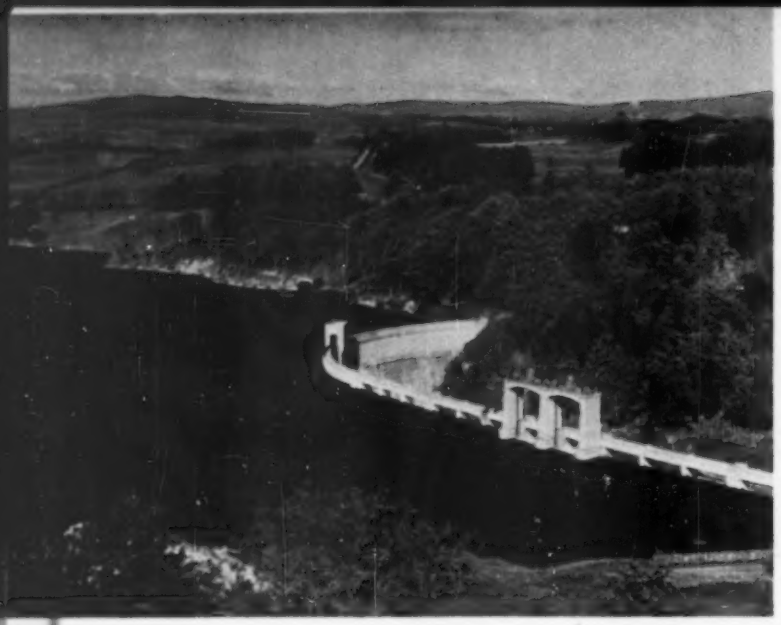

Fig. 1. This picture shows the Earlstoun Dam which provides a daily storage of water in the 100,000-kw Galloway hydroelectric scheme in Scotland.

A hydroelectric project of tremendous proportions is under way in the Scottish Highlands, a region of great annual rainfall and unparalleled natural storage. The North of Scotland Hydroelectric Board has already promoted 19 specific projects totalling an installed capacity of 630,000 kw. The total capacity of all projects in this great regional system of power development, when completed, will be over a million kilowatts

By **JAMES WILLIAMSON**
Consultant to the North of Scotland Hydroelectric Board

A GREAT WATER power development with plans for 102 hydroelectric schemes and an annual production of 6,300,000,000 kwh of electricity is going ahead in the Highlands of Scotland. The North of Scotland Hydro-Electric Board, formed by Act of Parliament in 1943, has already promoted 19 schemes with a total capacity of approximately 630,000 kw, and an annual output of about 1,600,000,000 kwh. The total output and capacity of all schemes, when completed, will be 1,041,750 kw and 3,017,500,000 kwh.

The Board supplies a population of about 700,000 people from steam, diesel and hydroelectric installations, having a total capacity of about 240,000 kw and an annual output of about 730 million kwh, of which one half is hydroelectric. Over 5000 miles of high and low tension line are required for current distribution, and extensions are under way.

The Board, in 1944, published a Development Scheme which, without covering the whole area, gave a list of 102 sites or areas proposed for investigation with an estimated annual output of over 6000 million kwh. This was followed by the promotion of a number of small schemes intended for immediate benefit to local communities by providing electricity at reasonable prices, and two large schemes of much wider scope, Sloy and Tummel-Garry. Other promotions followed. By the end of 1949 the schemes sanctioned comprised 28 stations with a capacity of about 600,000 kw, and an estimated annual output of about 1700 million kwh.

The largest station is at Loch Sloy with a total capacity of 130,450 kw. At Clune the capacity is 57,000 kw. At Errochty the capacity is 75,000 kw. It was at Loch Sloy, that Queen Elizabeth, on October 18th, closed the switch that started the generators.

A Scottish Beauty Spot

Glen Affric, one of Scotland's beauty spots, has a capacity of 66,000 kw and an annual output of 236 million kwh. Others are smaller with a range from Glascarnoch with 24,000 kw of capacity to Doe with a capacity of 2700 kw.

The Loch Sloy Station is designed for operation (at low load-factor) to overtake the peaks of the load which occur particularly in the winter season of heaviest demand. A concrete dam of the gravity buttress type creates storage of 1200 million cu ft in the basin of Loch Sloy. An extensive system of aqueducts and tunnels which tap remoter streams at high level increases the catchment area to 31 sq miles. A lined tunnel of horse-shoe shape, 15 ft 4 in. in diameter and two miles long conveys the water through Ben Vorlich, and a line of four pipes from 7 ft to 6 ft 4 in. in internal diameter and 1500 feet long delivers it to the Power Station at Inveruglas on the shore of Loch Lomond. The main works are approaching completion, and the first of the four generating sets was put on the line on March 6, 1950.

The Loch Sloy dam is a gravity buttress structure with a total length of 1160 ft and a maximum height of 160 ft, the average height along its length being about 100 ft. When completed, an arcaded top section will carry a continuous gravity wall supporting a roadway across the top of the dam. A spillway is at present under construction at the deepest section and there is a reinforced concrete valve tower at the center of the dam on the upstream side. This tower will project 36 ft above the top of the dam when completed, provision for the control of the intake of water to the main tunnel being made at the bottom of the tower. The total concrete volume of the dam will be about 200,000 cu yd. The buttresses are spaced at centers of 65 ft and are each 26 ft thick.

HYDRO SYSTEM Developing in SCOTTISH HIGHLANDS

In practice, the buttresses are concreted in two sections and a contraction gap about 6 ft wide is left between adjacent buttresses. The head of each buttress is concreted several lifts ahead of the stem, thus avoiding contraction cracks within the buttress itself, which is about 140 ft long at the base. The concrete is poured in lifts about 3 ft 6 in. high, panels of steel shuttering being bolted into the last completed lift and then raised up as the work proceeds. Small runabout cranes with pneumatic tires are stationed on the surface of the buttress to handle the shuttering panels, and they are lifted from one buttress to another, as required, by the cableway.

The contraction gaps are concreted in when the buttresses are at least three months old. A bitumen asbestos sheet is placed round the surfaces of each of the four chases, the gap being wedge-shaped. When the reservoir is filled, the hydrostatic pressure on the upstream face of the dam will act on this wedge, and this pressure, combined with the bitumen seal, will ensure watertightness.

The spillway is situated at the center of the dam, and is being built in two halves, each half spanning between two buttresses and separated from the other half by the center buttress. Each half consists of precast reinforced concrete slabs spanning between the buttresses and supported at rebates left in the corner of each buttress. The spillway terminates with a dispersing bucket, which will be submerged in a stilling pool at the toe of the dam where a concrete lined open channel leads under the two-span bridge into the natural course of the Inveruglas Water.

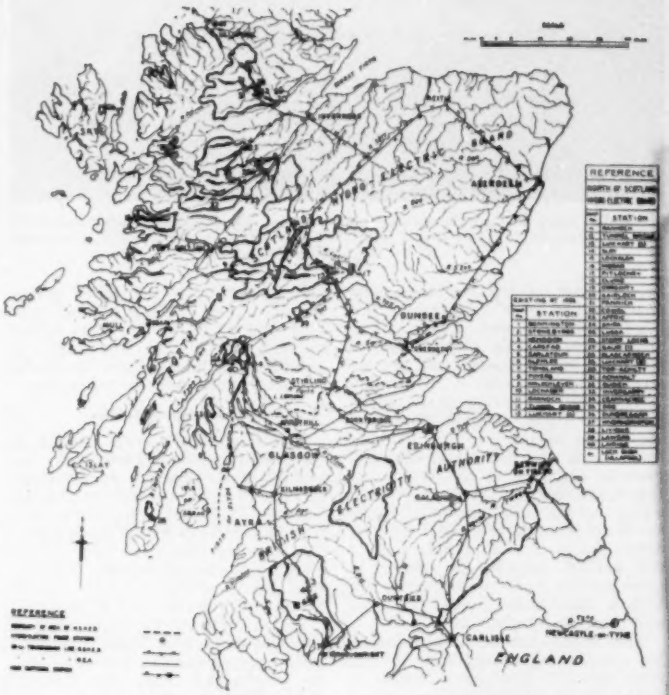

Fig. 2. This map shows the location of the new power stations sanctioned up to June 1950. A key to the various stations is given at the side of the map

Main Tunnel and Surge Shaft

The main flow of water from the reservoir to the power station passes from the intake at the foot of the intake tower into a bell-mouthed section leading under the dam from the gate opening in the tower, which is 19 ft by 10 ft, to a steel pipe of riveted construction, 13 ft 6 in. in diameter. This pipe is embedded in concrete in a trench passing under one of the buttresses; it falls gradually to obtain greater head of rock for tunnelling and turns towards the tunnel entrance in the high ground on the left bank of Inveruglas Water which it joins about 80 ft downstream of the dam.

The first section of the tunnel continues into the mountainside in the same direction until sufficient cover of rock is obtained, and than turns towards the surge shaft. At this point, the construction changes from a circular section 13 ft 6 in. in diameter with a reinforced concrete lining into a horse-shoe section with a maximum width of 15 ft 4 in. (equivalent diameter about 15 ft 8 in.) with a plain concrete lining. The first section of tunnel, with the circular section, is about 700 ft long. It is reinforced with 1½ in. diameter mild steel hoops at 6½ in. centers formed by welding together two semi-circular pieces and laced together with longitudinal rods. The rest of the main tunnel has a length of about 8200 ft and passes under Ben Vorlich which raises about 1700 ft above the tunnel invert.

When faults and soft regions were encountered, the tunnel was lined with a supporting framework of steel joists and occasionally with dry walling. These supports were left in place and concreted in when the tunnel was lined.

The surge shaft is situated about 500 ft inside the fork of the main tunnel; it is designed, in conjunction with the surge chambers, to limit the effects of water hammer and vertical swing of water under the worst conditions of rejecting or throwing on load at the power station. It is a vertical shaft, 245 ft high from the invert of the tunnel

Fig. 3. This shows the Loch Sloy dam under construction. This is a gravity buttress structure with a total length of 1160 ft and a maximum height of 160 ft. Total volume of concrete will be about 200,000 cu yd

to the floor of the top expansion chamber and 26 ft in diameter and lined with concrete. The surge chamber at the top of the shaft is 90 ft long by 38 ft wide, and is constructed with a vaulted roof, being 28 ft high at the center of the vault; it is also lined with concrete and the whole of the vault is in solid rock inside the mountain. The expansion chamber at the bottom of the surge shaft is divided into two equal halves, one connecting with the shaft on each side at a level just above the main tunnel. Each half of the bottom chamber is similar in cross section to the main tunnel but with a diminishing height, the roof and floor being sloped.

This surge chamber is also joined by a collecting tunnel 4500 ft long from the Allt Ardvorlich stream, it being more convenient to collect the water from this stream by a tunnel direct to the main tunnel than to join it to the northern system of aqueducts which flow into the north end of Loch Sloy.

The Pipe Line

The two 10 ft diameter steel pipes at the tunnel exit branch into four pipes, each with an internal diameter of seven feet at the top of pipe line reducing to 6 ft 4 in. at the power station. Each of these pipes supplies one of the four main turbo-alternators. The pipe line is about 1500 ft long with four large anchor blocks of reinforced concrete at the principal changes of direction or inclination. The uppermost anchor block supports a valve house at the commencement of the pipe line and the lowest block is at the power house. In between the anchor blocks, the pipes rest on concrete piers spaced at 48 ft centers, and are gently curved with horizontal or vertical curves of 1500 ft radius where required. An inclined service railway runs up beside the pipes to the valve house at the top, which is equipped with a 25 ton overhead traveling crane and servicing space.

The Power Station

The Loch Sloy power station is intended to be the control center for several of the Board's undertakings so that, in addition to the machinery hall, the south end of the power station is taken up by an administrative building. The machinery hall is 190 ft long and 52 ft wide and is a steel frame structure with a lightly reinforced concrete wall 12 in. thick.

In the Tummel-Garry Scheme of three stations, the Clunie and Pitlochry stations utilize regulated water discharged from the Tummel Bridge Station, which is now operated by the Board. The Errochty Station at the head of Loch Tummel uses water diverted from the head streams of the River Garry, and its discharge supplements the flow to the Clunie Station. Loch Tummel, dammed to form a balancing reservoir, feeds a main tunnel of 23 ft in diameter, about two miles long to supply that station.

A dam and river station at Pitlochry with two Kaplan sets each of 7500 kw. creates a further fall of 50 ft and a balancing reservoir to provide steady outflow. The Errochy Station, supplied from a catchment of 86 square miles through a main reservoir on the Errochty Water by a 6 mile tunnel will operate at low load factor. The Clunie and Pitlochry Stations come into production this year, the first set at Clunie having commenced operation last March.

The Fannish Scheme is notable for the large storage obtained in the deep Loch Fannich by under-water tapping. A main tunnel four miles long and ten feet in diameter conveys the water from a catchment of 56 square miles to the power station.

The 66,000 kw Affric Scheme obtains ample storage by damming two Lochs and joining them by a tunnel. From the latter loch a lined tunnel three miles long conveys the water to the Power Station.

Among other major schemes in progress or in preparation, the Shira Project is notable for a 40,000 kw vertical Francis set for a gross head of 965 ft, and the Lawers Scheme for a 30,000 kw horizontal twin-wheel Pelton set of 30,000 kw, under a gross head of 1360 feet.

Replacing the Oil Lamp

Staged schemes on the Inverness-shire River Garry and on the River Moriston are based on ample storage to be obtained in the four large Lochs in one of the wettest areas of the Highlands, with rainfall reaching locally to about 200 in. per annum. There are also four smaller schemes for local supplies in isolated districts of the west coast.

The aggregate capacity in stations which are sanctioned or in progress amounts to more than 600,000 kw, with an annual output of over 1600 million kwh. This probably represents a bare quarter of the ultimate linked development, and further major and minor schemes are being planned. The effects of such a program take time to develop, but thousands of remote Highland homes have already replaced the messy oil lamp and the kitchen grate by electric light and electric cookers and agriculture and local small industry has not been slow in taking up the Board's current.

To gain experience with the new form of power production by gas turbine, the Board has ordered a 12,500/15,000 kw generating set for installation in a steam station, and looking further ahead has initiated an investigation into the possibility of utilizing the extensive peat-fuel resources of the Highlands to provide the gas for local gas-turbine stations conveniently located for supplementing and balancing water-power production.

* * *

MANY EXPLANATIONS have been advanced to account for the production of electricity during thunderstorms. One of the most recent investigations suggests that voltages may be built up by the freezing action in the formation of glaze hail from impure thunderstorm water. Laboratory tests have shown, for example, that when a weak solution of ammonium hydroxide is frozen, a potential difference as great as 235 volts is generated between the ice and the remaining liquid.—*Ohmite News*

The PRACTICAL ENGINEER *and* ELECTRICIAN

ANDREW W. KRAMER, EDITOR

CAN YOU—AND WILL YOU—WRITE AN ARTICLE FOR POWER ENGINEERING ON PUTTING STEAM TURBINES INTO SERVICE?

This must NOT be merely the conventional article enumerating in order the various operations necessary. Rather it must be an article written from the point of view of the man who actually do the job and telling not only what they do but why they do it, what they think about, how they act, what they feel about it.

And don't tell us this type of thing cannot be done. It WAS done by John C. Gore, shortly before his unfortunate and untimely death in 1947. And it was done, to our great pride, in the pages of *Power Plant Engineering*, now *POWER ENGINEERING*.

In a series of articles in 1946 and 1947, Mr. Gore, a former boiler erecting engineer, boiler operator and all-around superlative power engineer, put into words the "feeling" of the man engaged in putting a big high-pressure steam generating unit into service and getting it "on the line" for the first time—the whole human "atmosphere" of a group of skilled workers teamed up on an interesting and important job.

Everybody who has ever had any contact with such a job has told us how well Mr. Gore expressed the anxiety, the tension, yet at the same time the confident and thorough knowledge of the engineers who do this. So many things to be thought of—so many new devices to be tuned up to work exactly as designed—so many safety measures to take for both men and equipment's sake—every detail to be thought of; and yet—could something go wrong that hasn't been foreseen?

Recently a number of readers have asked us if somebody could do the same thing in describing how turbines are put into service. Who'll volunteer to try it?

Before attempting it, you ought to read Mr. Gore's articles and if you don't have back issues containing them, the editors will gladly send you reprints of them. They are all from *Power Plant Engineering*.

Perhaps you could do the same sort of thing with the steam turbine. The way you tell it is even more important in this case than what you tell. If you think you'd like to try it, write the Editors and we'll talk it over with you. Special rates, of course!

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How to Cut Power Maintenance Time in Half

The use of motor operated tools can greatly reduce the amount of time necessary to remove and install large bolts on mechanical and electrical equipment in power plants when it becomes necessary to take such equipment down for inspection or maintenance

By A. R. RINGER
Application Engineer, Ingersoll-Rand Company

OVERHAULING a 30,000 kw turbine is more than a man-sized job and it often requires five to six weeks for completion. Most generating stations are faced with this repair task at some time or other — perhaps once a year, perhaps less frequently—whenever it's necessary, it's an expensive, time-consuming, laborious piece of work.

The Metropolitan Edison Co. of Reading, Pa., has learned how to take the kinks out of the job, as well as out of the backs of the men who work on it. By the substitution of power tools for handwork, they are saving time on the operation, and fatigue on the part of the employees.

Both air and electric power equipment are used for tearing down the turbine and putting it together again. An Ingersoll-Rand 577 air Impactool is used to remove the larger nuts which hold the cover and a size 4U electric Impactool, also made by Ingersoll-Rand and rated up to $\frac{3}{8}$ in. nut size, takes over on the smaller size nut-removing applications. Removal of the cover, normally held down with about 120-$2\frac{1}{4}$ in. bolts, requires the services of only two men with the air impact tool and takes six to seven hours to complete. The engineer in charge of the job estimated that the same operation with a sledge hammer and wrench would take at least 12 hours — saving about 50 per cent of the time with the air power tool. The application involves a $2\frac{1}{4}$ in. bolt with a $3\frac{5}{8}$ in. A. F. socket.

On three bolts in central position, closely surrounded by other bolts, a power tool could not be used because of insufficient space. On one of these bolts alone, a crew of 4 men, with hand wrench augmented by a piece of pipe for leverage, worked for almost an hour before the bolt was loosened. Had the position of these bolts enabled the operator to use the air impact tool, it is estimated that loosening would have been effected in 10 minutes or less, with only two men on the job.

In addition to removing nuts securing the high pressure cylinder cover in order to repair and clean the spindles, the air impact tool is used to remove the pedestal from the foundation in order to reach the cylinders, and to remove the 2 in. acorn nuts which hold the stay bolt in the cylinder exhaust. This is sometimes necessary to renew the blade ring.

The smaller-size electric Impactool is used on the $\frac{3}{8}$ in. nuts holding the discharge to the auxiliary oil pump, in a routine cleaning of the

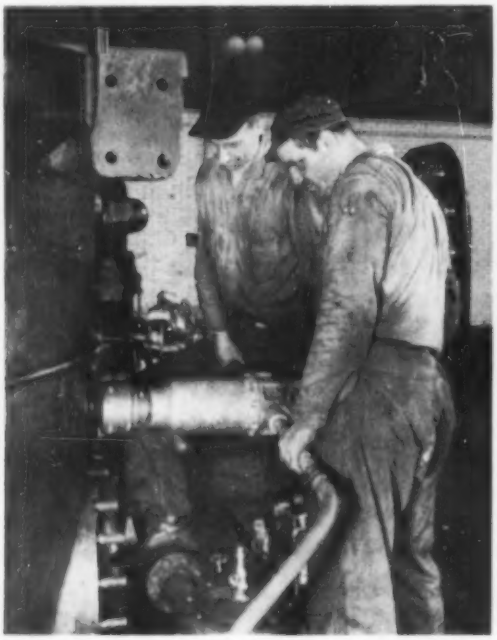


Fig. 1. In disassembling this 30,000-kw turbine for overhaul an air-powered Impactool is being used. Here it is being used to remove $2\frac{1}{4}$-in bolts which hold the pedestal to the foundation

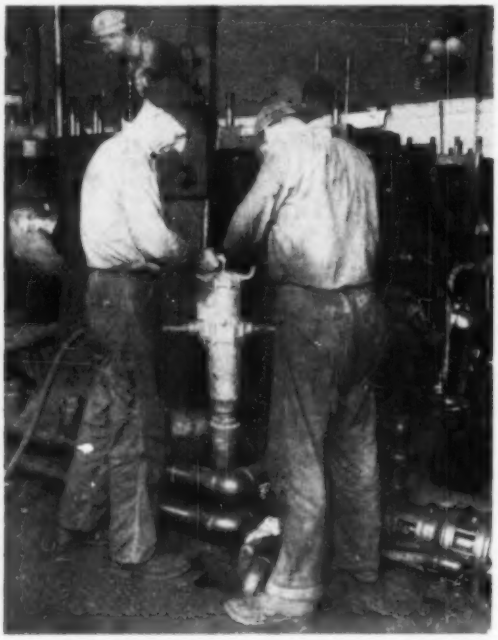


Fig. 2. The air-powered impact tool is also used for taking the 2-in. nuts off the high pressure cylinder cover to repair the turbine spindles. In this view the tool is being used on the horizontal joint studs which hold the cover

pump while overhauling the entire turbine. It is estimated that the electric tool, which operates on the same impact principle as the air impact tool, also saves at least 50 percent of the nut-removing time.

The electric power tool is used at the Philadelphia Electric Company's Delaware Station with a Filister head screw to remove the dust cover housing from a metal-enclosed 60 cycle bus rated at 4000 amp and 15,000 v. The bus runs the entire length of the switch house at the generating station. The housing, 22 in. in diameter, is split lengthwise and fastened on each side with 5/16 in. diameter Filister head screws. Each screw is removed in about 3 seconds with the electric impact tool — which, it is estimated, is about five times as fast as it can be done with a hand wrench — or a saving of 80 per cent of the time just in removing the screws. It is estimated that removal of the dust cover for insulation, new gaskets, and a different type of dust proofing involves the removal of 6000-7000 screws — a job normally requiring several months when an ordinary hand wrench is used. With the electric impact tool, it takes a crew of 14 men working an 8 hour shift just five days to complete a section. The field engineer in charge of the job estimated that the time saved by the power tool on each of the 6 sections amounted to about 300 man hours — or 30 per cent of the man hours on the entire job of disassembly, dust-proofing, and re-assembly. The electric impact tool has been so useful on this bus maintenance job that the manufacturer of the bus bought several of these power tools for production assembly work.

The foreman on the job also reported that the electric impact tool is used to remove ½ in. bolts from heads of tap changers to inspect the changers, and that, on all operations, workers are much less fatigued at the end of the shift.

Reason for the significant time and labor-saving results of these air and electric impact tools lies in the additional power which is automatically available whenever the nut is corroded, jammed, or offers removal resistance for any reason. An impact tool operates on the intermittent torque principle. The resistance offered by the nut winds up the patented Impact Mechanism, which delivers thousands of rotary impacts per minute — a source of extra power which spins off the nut quickly and easily, and which is not available with hand wrenches or with the ordinary continuous torque power wrench.

Power impact tools — both air and electric — have the additional advantage of torque action without torque reaction. No kickback or twisting is transmitted to the operator. This feature greatly reduces operator fatigue and also makes it possible to hold the small electric tools with one hand, and thereby reach into confined spaces and parts of equipment which are ordinarily not readily accessible.

Since the motor is reversible, the power can be applied to drive or remove fastenings at the operator's will simply by turning the motor housing cap to the proper position. In addition to removing rusted or frozen nuts, power impact can thus be used for drawing nuts and cap screws tight.

With impact tools the motor continues to run at normal speed even if the spindle stalls completely. This eliminates motor burnout in the electric impact tools, often a common source of electric tool failure, and a costly one to repair. Just as the rotary impact principle results in a time-saving advantage, the elimination of motor burnout results in maintenance economy and a reduction in tool down-time.

Although impact tools find their greatest use in the power field on nut-running and screw-driving applications, they can also be used, with standard accessories for extracting broken cap screws and studs; driving and removing studs; reaming; drilling steel, wood, or masonry; tapping; wire brushing and hole sawing.

The air operated Impactool is designed to handle large studs, bolts, nuts and cap screws from 1¼ in. up to 2 in. thread size. The electric Impactool (size 4U) is rated up to ⅜ in. bolt size, and its bigger brother (size 8U) is rated up to ⅝ in. bolt size. Both types of impact tools — whether air or electric driven — furnish plenty of power for heavy and hard work, although their weight, for power delivered, is comparatively light. The 577 air impact tool weighs 72 pounds (less socket) due to the extensive use of magnesium in the housings. The smaller electric impact tool (less cable) weighs 6 lb, 8 oz, and the larger electric impact tool weighs 9 lb, 14 oz. Both

Fig. 3-A. (Left) Here the electric impact tool is being used to remove the smaller sized 5/16-in. screws from a 6-section bus cover running the entire length of the switch house

Fig. 3-B. (Center) Another view of the disassembly of the bus cover, showing the ease with which small screws can be removed

Fig. 3-C. (Above) The motor operated tool is particularly advantageous where the equipment is difficult of access

electric tools are light and well-balanced.

The chief engineer of one power plant is so enthusiastic about the time and cost saving features of these power driven impact tools that he ordered power impact tools into the generating station before he would work on the job.

Ash Residue in Fuel Oils

Impurities in Fuel Oils . . . Method of Testing for Ash . . . Salt or Chloride Test . . . Quantity of Salt Present . . . Salt Content of Fuel Oils and Crudes

By **PAUL F. SCHMIDT**
Allied Oil Co., Inc., Cleveland, Ohio

FEW PEOPLE have any conception of some of the foreign materials found in heavy fuel oils. These materials are all impurities. To help to understand how and why they are present, it should be remembered that the crude oils come from thousands of feet beneath the surface of the earth, where they are usually mixed with water, mud, and sand. Most of these contaminates are eventually drained off from the crude before transporting to, and at the refinery, but small amounts still remain suspended and emulsified with the crude.

While some of these sediments and impurities from the crude which eventually end up in the heavy fuel oils are combustible, therefore capable of burning and disappearing, there is some noncombustible material present. This material, which is unable to burn, forms a residue called ash. While the amount is usually quite small, it can still cause trouble, when oils with certain types of ash are used in particular operations. There is no ash in No. 2 oils, or distillates, but some will be found in No. 4, 5, and 6 residual oils.

Method of Testing

The test for ash is simple. The residue left after burning the oil in the presence of air is called the ash. The oil is first heated to ignite the volatile vapors, and when these have finished burning, the temperature is increased in order to burn away all the carbonaceous material, leaving only the non-combustible ash.

Amount of Ash in Fuel Oils

The total amount of ash varies, but the following examples will present some idea.

No. 4 oil .....nil to 0.005%
No. 5 oil .....nil to 0.075%
No. 6 oil .....0.005% to 0.100%

Maximum Ash Permissible

According to the standardized fuel oil specifications, the maximum amount of ash permissible is as follows:

No. 4 oil .....0.10% maximum
No. 5 oil .....0.10% maximum
No. 6 oil .....no limit specified

These percentages are quite large for ash content of No. 4 and 5 oils, but very seldom do these oils possess such a large amount of ash. Correctly and properly refined fuel oils will have much lower ash content than the maximum allowed. If the total ash content does exceed the maximum as set forth in the specifications, there will undoubtedly occur some trouble. While there is no limit in No. 6 oils, the amount is usually not much higher than in No. 5 oils.

Composition of Ash

The ash may be composed of many substances, such as tank scale or rust, dirt and sand, but in most cases it is inorganic salts. In some poorly and improperly handled residual oils, there will be found the catalytic agent from the refinery towers. This is not common, but if present will be found in the oil as ash. These salts are chemical compounds which vary with the different types of crude, and with source of the crude. They are generally found in solution with the water in the crude, or as sediment, which during the refining process, become concentrated in the residual oils.

To illustrate, compounds of silicon, iron, calcium, magnesium, vanadium, and sodium are a few that may be present. The type, number, and amount of these different compounds will vary greatly, but the following illustration will present some idea of what may be found in the ash content of heavy fuel oils.

Silicon compounds	0.0310%
Calcium compounds	0.0150%
Iron compounds	0.0250%
Manganese compounds	0.004%
Vanadium compounds	0.001%
Sodium compounds	0.0300%

You will notice that the amounts are quite small, but in some industries even these small amounts will cause trouble.

In the glass and ceramic industries, vanadium and iron content are important. Some of these impurities are absorbed by the manufactured articles, thereby spoiling them. Pitting and discoloration being the greatest trouble. A recent specification for residual oils, limited the vanadium content of the fuel, for use in gas turbines.

Some of the ash, particularly the chemical compounds, can cause deterioration of the refractory materials, in the combustion chamber. Abrasive ash can cause erosion of burner tips and mechanical wear in pumps, valves, and delicate control instruments.

If the ash content is large, it may settle on the flues, or heating surfaces of a boiler, causing loss of heat transfer, but if the amount is normal or small, it generally goes up the smokestack.

Salt or Chloride Content

In some specifications for heavy fuel oils, there is a maximum salt or chloride content listed. These salts are included in the total ash content, but are sometimes specified separately, so we will discuss them briefly.

These salts are chemical compounds, usually sodium, calcium and magnesium chlorides. Sodium chlorides are generally found in the largest quantity. The total salt or chloride content is expressed as sodium chloride, and includes all the different chlorides present.

The method of testing for chlorides is a chemical one, and would be hard to understand for one not familiar with analytical chemistry, so no description of this test is included. Any book on chemical analysis will have it for those interested.

Source of Salt Content

A dry oil would contain no salt, as it is the small percentage of water present in the oil, that holds the salt. The original salt is found in the crude oil, but it becomes concentrated in the water and sediment of the heavy oils, combined with the other ash-producing materials, during the refining process.

The refining equipment is subjected to excessive corrosion by the presence of large amounts of salt. To overcome this, crude oils are usually

Salt Content of Various Heavy Fuel Oils and Crudes

Pounds per 1000 barrels	Pounds per gallon	
10	0.0002	Heavy fuel oil
17	0.0004	
21	0.0005	
48	0.0010	
65	0.0015	
144	0.0034	
171	0.0040	
55	0.0013	Crude oil
81	0.0019	
191	0.0045	

desalted before refining, but not all of the salt is removed. A large percentage is taken out, which in turn helps reduce the corrosion and the amount eventually found in the residual oils.

Quantity of Salt Present

The usual method of describing the amount of salt or chloride, is in pounds per 1000 barrels of oil, and to bring this down to easy understanding, the following illustrations will help to visualize these amounts. As you will see, the amounts present in heavy fuel oils vary a great deal. This is directly responsible to the amount present in the crude oil, at the time of refining, as well as, the source. Some crudes may have a large amount of water, but only a little salt content, and the reverse is also true.

You will note that the amounts are small, so very infrequently, any trouble is encountered due to this type of ash. If the amount is large the same difficulties may be experienced to the refractory materials, and mechanical parts as described in the part on total ash.

In summing up the remarks about ash and salt present in residual fuel oils, these impurities can be ignored for most combustion operations, except in those industries where the products manufactured, or different types of operations, warrants special consideration, such as previously described, because of the troubles encountered by deposits of harmful ash.

How to Stop One Common Cause of Chronic Superheater Tube Failures

Faulty operating methods are second leading cause of repeated superheater tube failures . . . Internal deposits head the list . . . Difference between heat absorption in boiler tubes and superheater tubes . . . How to handle superheater drains in starting up and shutting down . . . Don't throttle drains; open them wide; the manufacturer has designed them for it . . . What to do if you have to get a boiler on the line fast . . . Time required for proper superheater drainage may be longer than usually allowed

WHEN repeated superheater tube failures are encountered in a boiler installation, and it has been determined that internal deposits are not the cause, the boiler firing practices should be checked for the source of trouble. According to the records of the Hartford Steam Boiler Inspection and Insurance Co., faulty operating practices rank second in the list of various causes of superheater tube failures, internal deposits head the list.

Some boiler operators assume that the superheater can function successfully under any firing condition that is satisfactory for the boiler proper. This assumption is not correct, so there are times when the firing rate should be controlled with special consideration to superheater conditions. This is particularly true when the boiler is being started up, or shut down, as will be easily recognized when conditions in the superheater at such periods are compared with boiler tube conditions.

Boiler Tube vs. Superheater Tube Conditions

When the proper boiler water level is maintained, the boiler tubes are always in contact with water, which will absorb heat conducted through the tube walls. As the water absorbs heat, it circulates through the boiler, and this continual heat absorption and circulation combine to keep the tubes at safe temperatures. The action continues even though the boiler may not be delivering steam.

A different situation exists in the superheater tubes. Steam, instead of water, is the cooling medium for the superheater, but no steam will flow through its tubes unless there is a pressure differential between the inlet and outlet headers, and the tubes are clear of condensate. In order to obtain a pressure differential, steam must be passing out of the superheater or, in other words, it must be delivering steam.

Starting and Stopping

When a boiler is being started up, the superheater tubes will be subjected to the heat of hot gases, but no steam will pass through them until the boiler water has reached the steaming temperature and the header valves have been opened. Even then, the steam will only pass through those tubes which have been cleared of condensate. Likewise, when a boiler is suddenly taken off the line, or loses its load, heat will continue to be applied to the superheater tubes for a time, but no steam will pass through the tubes to cool them, unless the superheater safety valves are blowing.

It is obvious, from these points of

Excessive firing rate and too rapid pressure rise during starting-up period caused rupture of this pendant-type superheater tube. Boiler was put on line 4 hr after lighting-off

difference between the action in superheater tubes as compared to boiler tubes, that special protection must be given to the superheater when starting up or shutting down. To provide this necessary protection, superheaters are equipped with drain lines which, when properly used in conjunction with correct control of the firing rate, will prevent overheating. Following details of how this can be done were given recently in *The Locomotive*, published by Hartford.

Superheater Outlet Drains

A drain line is installed at the superheater outlet-header. This line is provided for the purpose of obtaining circulation through the superheater at times when the boiler is being fired but is not delivering steam through the main line. When starting up, steam should be voided by keeping the drain valve on the outlet header wide open until the boiler has been placed on the line. Too frequently, an operator, having in mind the saving of steam, will open the line only partially. This permits some steam to circulate in the superheater, but it is not likely to be sufficient for adequate protection. The superheater drain is designed by the manufacturer according to the requirements of the particular installation, and the size normally selected will void the correct amount of steam for adequate protection only when the line is wide open. This fact should be given full recognition by operators, for it is far better to lose a few dollars worth of steam than hundreds of dollars worth of superheater tubing.

In some plants, particularly central stations, it is sometimes necessary to place a boiler on the line rapidly. This requires a large release of heat in the furnace in order to generate steam quickly. Under such conditions, a large volume of steam must pass at high velocity through the superheater and this requires drain lines larger than those usually furnished. Under extreme conditions it may even be necessary to furnish steam from other boilers in sufficient quantity to keep the superheater cool until the unit is placed on the line.

When a boiler loses its load, or is taken off the line, superheater conditions are similar to the starting-up period, and similar precautions must be taken. The superheater outlet header-drain should be opened wide as soon as the main-steam-line valve is closed, or preferably a moment before the main valve is closed. The drain valve should then remain open until the boiler is placed on the line again.

At the superheater inlet-header a drain is provided for removing condensate when starting up, in order to permit a free flow of steam through the superheater. The valves in this line should be opened when the boiler is to be started, and should remain open until all condensate has been removed.

If the superheater is of the inverted type, the condensate will collect in the headers where it can readily be removed by the use of the drain lines. However, in pendent-type superheaters the headers are above the tubes, and the condensate cannot be removed by gravity drainage. The most common and most reliable method for clearing the pendent type is to evaporate the condensate by firing the boiler slowly to avoid excessive flue gas temperatures at the superheater. It should be borne in mind, however, that when the boiler begins to generate steam some of the tubes will be blown clear by the steam pressure, but the remainder will still contain trapped condensate, and the firing rate should be held down until all tubes are clear.

The length of time required to clear the superheater of all condensate will vary with the size and type of boiler, but according to a series of tests which were made in a number of plants, the time generally allowed by operators is not sufficient. The tests were made on boilers ordinarily placed on the line within 2 or 4 hr after starting to fire. In the study, thermocouples were attached to selected tubes throughout the superheaters, and readings were taken during the starting-up periods. The readings showed that the time required to clear all superheater tubes and establish free circulation was more than double that customarily allowed, and in some cases an allowance of more than 12 hr was necessary.

* * *

AN AMAZING new battery in which the ampere-hour efficiency approaches 100% and the energy efficiency is 85% is now available in capacities ranging from 0.5 to 40 ampere-hours. The new battery utilizes a silver cell in its design and weighs from one-third to one-fifth as much as conventional batteries. It is reported to be resistant to mechanical shock and can withstand heavy discharge currents without damage.—*Ohmite News*

"But, Henry, if yuh'd help with the work around here a little yuh wouldn't have to take these keep fit exercises!"

Fig. 1. Weighing on 6000 lb the Trackmobile has plenty of power for pulling fully loaded railway cars

Trackmobile Makes Railway Car Handling Easy

THE PICTURES on this page show a new Trackmobile developed by the Whiting Corporation for hauling, spotting, and switching railway cars. Developed for general use, it should be of considerable value around power stations in handling coal cars.

It is a small, compact, gasoline-powered car designed to travel either on railway tracks or on the ground. A simple control makes it possible to change from one method of travel to the other in just 30 seconds.

The feature that makes this car really unique is the hydraulic jack which, when the trackmobile is coupled to the railway car, raises the railway slightly so that part of the car's weight is transferred to the trackmobile. This greatly increases the tractive effort and enables the little car to develop a maximum drawbar pull of 7350 lb.

The Trackmobile uses four standard steel wheels for track travel. The four rubber-tired wheels for ground travel are hydraulically retracted when the trackmobile is positioned for track operation. One operator easily controls the transfer from one set of wheels to the other. The maximum ground speed is 20 miles per hour; the track speed varies with the load.

As will be seen from the photograph (Fig. 1) the driver's seat is placed so that he has full vision in either direction on his side of the track. If necessary, the trackmobile can be placed between two groups of railway cars so as to pull one group while pushing the others. The weight of the trackmobile itself is 6000 lb, however by virtue of the arrangement whereby part of the weight of the railway car is transferred to the Trackmobile, the following tractive effort in pounds — drawbar pull is obtained:

1st gear at 1.5 mph — 7350 llb
2nd gear at 2.5 mph — 4700 lb
3rd gear at 4.0 mph — 3200 lb
4th gear at 9.0 mph — 1100 lb

The device is powered by an L type, 4-cycle, 4-cylinder gasoline engine, rate at 60 Bhp (Max) at 4000 rpm and developing a maximum of 106 foot-lb at 2000 rpm. The engine is water cooled, the cooling system using a deep-core fin radiator with conventional engine-driven water pump and a belt-driven fan. The motor clutch is a single plate, heavy duty type, 9 in. in diameter, transmitting maximum driving torque under most severe conditions. The transmission has four speeds—ahead and reverse — with standard automotive type selective shifting. The mechanical brake is drive-shaft mounted with ample capacity to hold the load under normal operating conditions but air brakes can be provided if desired. The engine has standard battery ignition and the generator has ample capacity for lights and signalling devices. When operating on road wheels, the car has a turning radius of 20 feet.

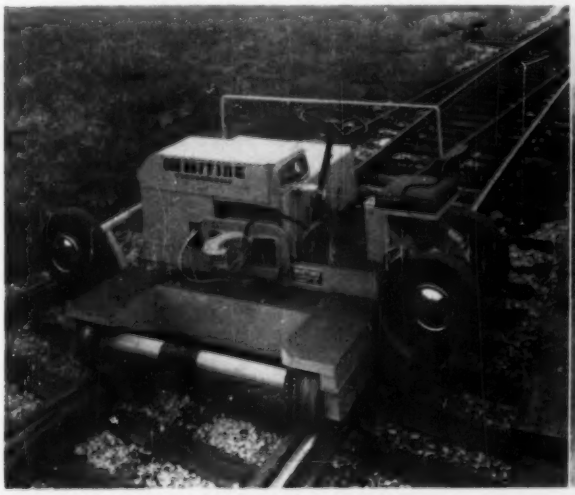


Fig. 2. Close-up showing the four standard car wheels for track travel and the four rubber tired wheels for ground travel

Fig. 3 Showing how the car is placed over the railway track by the rubber tired wheels. As the latter rise, the car wheels engage the track

How to Space Your Pipe Supports Correctly

Here is a simple, easy-to-read chart for determining proper distance between pipe supports . . . Horizontal pipe line should be pitched downward so that outlet of each span is lower than maximum sag . . . Weight of pipe and contents may cause pipe to sag between supports, form pockets in steam lines where condensate may collect unless pipe is properly pitched to drain it . . .

WHEN a horizontal pipe line is supported at intermediate points, sagging of the pipe may occur between these supports. The amount of sag is dependent upon the weight of the pipe and the fluid, plus any insulation, valves or fittings which may be included in the line.

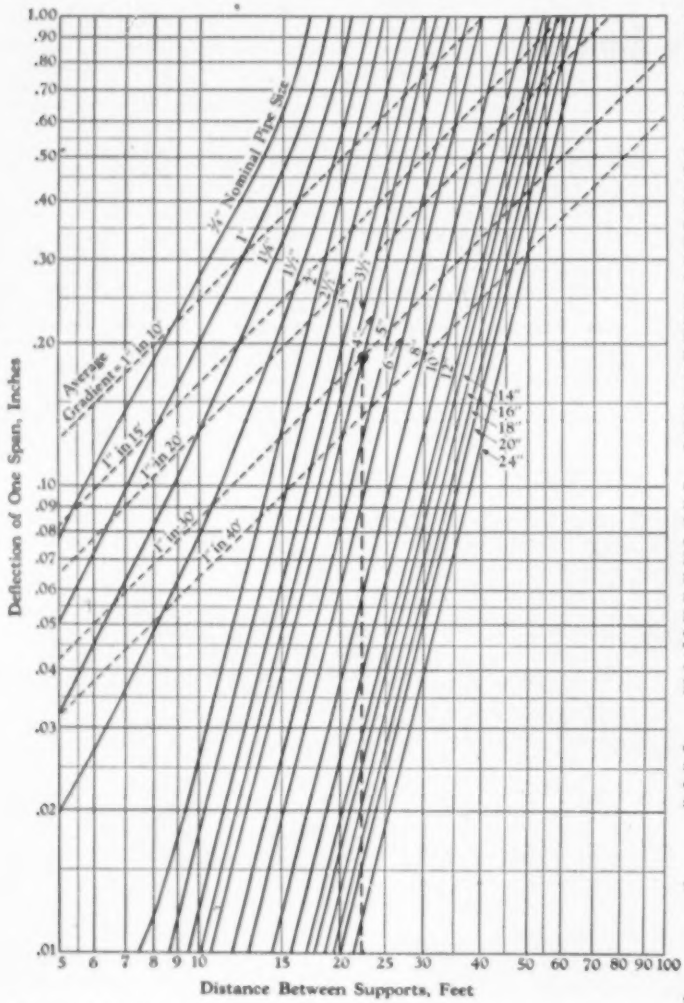


Chart showing deflection of horizontal pipe lines, for determining correct distance between pipe supports. Based on standard pipe filled with water. Use of chart explained in text, for example in which average gradient of a 4-in. standard pipe is 1 in. in 30 ft

If the pipe line is installed with no downward pitch, pockets may form in each span. In lines conveying steam, condensate may collect in these pockets. To eliminate them, the line should be pitched downward so that the outlet of each span is lower than the maximum sag.

Crane engineers have conducted tests to determine the deflection of horizontal standard pipe lines filled with water, in pipe sizes ¾-inch to 4-inch inclusive. The results, recently reported in *Valve World*, have indicated that, for pipe larger than 2-in. with supports having center to center dimensions greater than 10 ft, the resultant deflection is less than that determined by the use of the formula for a uniformly loaded pipe fixed at both ends. For pipe sizes 2-in. and smaller, the test deflection was in excess of that determined by the formula for pipe having fixed ends. For the shorter spans, it approached the deflection as determined by the use of the formula for pipe lines having unrestrained ends.

The accompanying chart gives the deflection, for varying spans, of horizontal standard pipe lines filled with water. It is based upon the results obtained from tests for pipe sizes 2-in. and smaller, and upon the formula for fixed ends for the larger sizes of pipe. The deflection values given on the chart are twice those obtained from test or calculations. This is done to compensate for any variables, including weight of insulation, etc.

Formula

The formula given below indicates the vertical distance that the span must be pitched so that the outlet is lower than the maximum sag of the pipe.

$$h = \frac{144S^2y}{36S^2 - y^2}$$

where:

h = Difference in elevation of span ends, inches
S = Length of one span, feet
y = Deflection of one span, inches

By eliminating the unconsequential term "$-y^2$" from the denominator, the formula reduces to:

$$h = 4y$$

The pitch of pipe spans, called the Average Gradient, is a ratio between the drop in elevation and the length of the span. This is expressed as so many inches in a certain number of feet:

$$\text{Average Gradient} = \frac{4y}{S}$$

The dotted lines as shown on the chart are plotted from the above formula and indicate average gradients of 1 in. in 10 ft, 1 in. in 15 ft, 1 in. in 20 ft, 1 in. in 30 ft, 1 in. in 40 ft.

Typical Problem

What is the maximum permissible distance between supports for a 4-in. standard pipe line assuming a desired pitch or average gradient of 1 in. in 30 ft.

Solution

From the intersection of the diagonal dotted line for an average gradient of 1 in. in 30 ft and the diagonal solid line for 4-in. pipe, draw a vertical line (as shown on chart). Where this line intersects the bottom horizontal scale, it shows that the maximum span is approximately 22 ft.

The Hand of the Power Plant Worker

By Dr. W. SCHWEISHEIMER

HANDS: in every occupation and every trade they are the most important tools, they are irreplaceable. They must be in good, healthy and efficient shape in order to guarantee efficiency to the men occupied in power plants and electrical work.

The skin of every hand, of every finger, shows certain lines that are different in every single man. They enable the identification of a person through fingerprinting. In workers who are handling heavy materials such as metal parts, heavy wires, etc., these lines may be absent temporarily and fingerprinting may be without success. This absence, however, is only of short duration. The *papillary lines* of the fingertips are promptly reformed when work is discontinued. But, as Dr. Ronchese pointed out, if an electrician is killed at work and his body lies unidentified and no help is to be obtained from his fingertips, other means of identification may become useful. This is the case in which professional calluses, worn out fingertips or scars may supply the identifying clue.

Callosities of the Hand

The changes which the workers' hand suffers under the permanent influence of mechanical, chemical, thermal (heat and cold) irritations, are numerous. Such changes are frequently characteristic of certain occupations and are regarded as professional stigmata or signs. Burns frequently produce lasting signs on the hands of electricians and workers in power plants. Skin grafting may be necessary after severe electric burns.

Calluses or callosities are circumscribed patches of hard, thick skin. Actually the callosity is a form of protection of the body against harmful pressure by a tool or any hard object. Permanent pressure would injure important parts in the deeper layers of the hand; the developing callus represents actually a sort of protective dam that diminishes the strength of the pressure. Callous hands are less likely to conduct the electric current; callosities may play the part of insulating material.

Excessive Perspiration

On the other hand, excessive perspiration (hyperidrosis) of the hands is an excellent conductor for the electric current. It is an unpleasant handicap for the worker who has to use wires, insulators and switches. There are many sweat glands in the skin of the hands, they are particularly numerous on the palms. The sweat evaporates quickly, drawing heat from the skin, and consequently the hands feel cold and wet. Excessive perspiration is a distressing condition for the electrician and power plant worker and may even interfere with his usefulness, for moist hands soil everything they touch.

Cause of the trouble may be some form of anemia or another general condition, or it may be a local condition of the skin of the hand. The knowledge that one's hands are cold and clammy may add to the embarrassment. The fear alone of shaking hands with another person may be sufficient to produce excessive perspiration. Any emotional upset tends to increase the secretion. For treatment astringent lotions and powders are often used. Soaking the hands in hot water for a short time gives relief. Recommended are a one-percent solution of formaldehyde (which, however, is not tolerated by everyone), or a one-percent solution of quinine and tannic acid in dilute alcohol or Eau de Cologne.

Allergic Hands

If an electrician or power plant worker is allergic to certain substances with which he has to work, he may develop an unpleasant eczema. Such skin inflammation affects the hands or fingers or forearms. While pain is rare, itching is common, particularly when the hands are exposed to heat. In the chronic form the skin of the hand becomes

thickened, with scaly or weeping patches.

It is obvious that in America with its modern working methods, such hand irritations are less frequent than in European countries. Personal sensitivity (allergy) may be the cause of the ailment. The skin is sensitive to a substance that usually is non-irritating. There are so many materials used in the daily work of electricians and power plant workers — starting from brass of

switches and measuring instruments to the synthetic waxes, rubber, oils and resins of insulating wire and the carbon electrodes of electro-thermal apparatus — that it might be hard to discover the actually irritating material. The modern skin test or patch test allows to find out whether the employee is sensitive to a certain material. This takes patience.

Trembling Hands

Trembling of the hands (tremor) is most unpleasant; the working ability of electricians and power plant workers is impaired by it. Still it is astounding to see older men with stiff fingers and arthritis-bent joints and trembling hands carry out fine work with absolute reliability. This indeed is a victory of Will over Matter! Sometimes exhaustion after long working hours may cause the trembling of the fingers, and a few days of rest or a good night's sleep will restore normal conditions. General conditions may be the cause such as anemia, convalescence after serious illness, heart conditions, etc. Certain changes in the central nervous system will result in trembling hands; it is not always possible to cure these conditions. Intoxication with nicotine, alcohol or industrial poisons may produce trembling hands.

We all know that mental excitement can produce temporary trembling of the hands. It will disappear with disappearance of the excitement or emotional upset. When nicotine or alcohol in abundance is at the root of the disturbance, the habit has to be discontinued for a long time. A medical checkup is strongly indicated when trembling of the hands is a persisting symptom.

Infections of the Hands

Industrial statistics have shown that infections of the hand generally form the major injuries which lead to partial and permanent disabilities. The injuries later may become infected. As Sumner L. Koch puts it: "The trivial hand injury, promptly and accurately cared for, goes on to rapid recovery; neglected it may result in serious infection."

Though hand injuries form the most common type of accidents in power plants and the electrical industry, serious infections are rare when there is the proper medical care immediately after the occurrence of the injury. Good first aid treatment consists in immediate application of a sterile dressing—and nothing more. Siler stresses one fact that obviously the best treatment of injuries is prevention of any further harm, and this is only attainable as the result of permanent cooperation and the sharing of responsibility by the employer, the employee and the physician. In more severe infections of the hand the use of the modern chemical methods of sulfa compounds and of penicillin marks a remarkable achievement in the treatment of wounds and injuries.

Most pustules on the hands of electrical and power plant workers are not of dangerous infectious origin, but are simple furuncles or boils. The infections occur mainly on those parts of the skin that are exposed to friction or injury. After some days or a week the painful boil is ripe. It ruptures and its yellowish-white content is extruded or may else be removed mechanically. Unhygienic working conditions surely have their influence on growth and frequency of boils, and the general condition of a worker may predispose to the infection. In all cases of repeated boils and especially in extended general furunculosis it is advisable to test the urine for sugar since a diabetic condition favors the occurrence of furuncles.

RHEOSTAT SIZE DECREASED BY TAPERED RESISTANCES

THE ADVANTAGES of the tapered type of rheostat in producing more uniform control is well known. Another, and very important advantage of a tapered winding or an arrangement of separate resistance in tapered sequence, is its ability to decrease the rheostat size required. As pointed out in a recent issue of *Ohmite News*, the tapered principle can be applied to all sizes of rheostat installations.

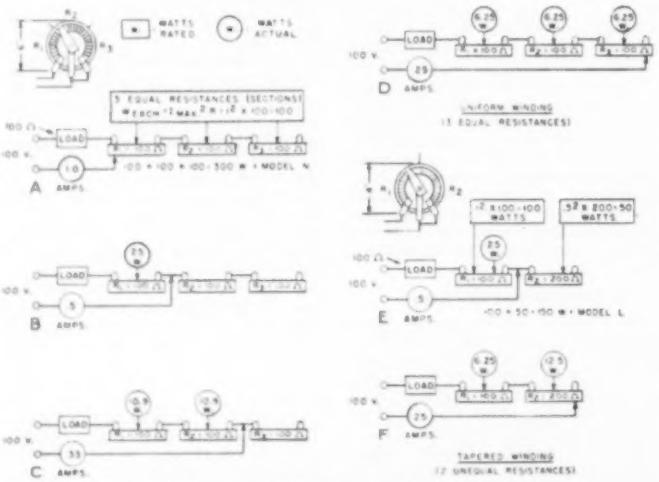
In the operation of any rheostat, when the moving contact is on the first turn of wire or ribbon, this turn must carry the maximum current. As resistance is placed in the circuit, however, the succeeding turns never have to carry more than a certain fraction of the maximum current, because the current tapers off from the maximum to some minimum value.

How this change of current is taken advantage of in a tapered winding, is shown in the illustration.

(A) diagrams a 300-ohm uniformly wound rheostat which, it is assumed, consists of 3 equal sections R_1, R_2 and R_3. These sections, in turn, are represented by the three fixed resistors connected in series. It can be seen that the wattage rating for R_1 (and for R_2 and R_3, as they are assumed to be equal) is $W = I^2_{max.} R$ or $W = 1^2 \times 100 = 100$ watts. Therefore, the uniformly wound rheostat must have a rating of 300 watts. Sketches (B), (C) and (D) show how the current and wattage in each section varies as the contact is moved. While the values given apply to the assumed case only, they illustrate how the last two resistors (or section of the rheostat) dissipate less wattage than the first.

Diagram (E) shows a two section tapered rheostat, also of 300 ohms total resistance, in which the first section is still 100 ohms, but in which the second section is 200 ohms. The wattage rating of the first section still must be $I^2_{max.} R_1 = 1^2 \times 100 = 100$ watts. But the rating of the second section need be only $0.5^2 \times 200 = 50$ watts. The total rating required is then only $100 + 50 = 150$ watts.

The particular rheostat design worked out in this example is merely incidental to the purpose of explaining the effect of a tapered winding, and is not to be considered representative of an actual taper for this case.



Rheostat hook-ups showing the principle of the tapered resistance

Basic Power Plant FIGURING

By **WILLIAM H. ENGELMAN**, Mechanical Engineer
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How to Buy the Best Coal for YOUR Power Plant

Table I. Cost of coal as received or as fired, in cents per million Btu, based on a cost of $1 per ton delivered, for heat contents of 9000 to 15,000 Btu per lb

Btu per lb as rec'd ↓ + →	0	10	20	30	40	50	60	70	80	90
9,000	5.556	5.549	5.543	5.537	5.531	5.525	5.519	5.513	5.507	5.501
9,100	5.495	5.488	5.482	5.476	5.470	5.464	5.459	5.453	5.447	5.441
9,200	5.435	5.429	5.423	5.417	5.411	5.405	5.400	5.394	5.388	5.382
9,300	5.376	5.371	5.365	5.359	5.353	5.348	5.342	5.336	5.330	5.325
9,400	5.319	5.313	5.308	5.302	5.297	5.291	5.285	5.280	5.274	5.269
9,500	5.263	5.258	5.252	5.247	5.241	5.236	5.230	5.225	5.219	5.214
9,600	5.208	5.203	5.198	5.192	5.187	5.181	5.176	5.171	5.165	5.160
9,700	5.155	5.149	5.144	5.139	5.133	5.128	5.123	5.118	5.112	5.107
9,800	5.102	5.097	5.092	5.086	5.081	5.076	5.071	5.066	5.061	5.056
9,900	5.051	5.045	5.040	5.035	5.030	5.025	5.020	5.015	5.010	5.005
10,000	5.000	4.995	4.990	4.985	4.980	4.975	4.970	4.965	4.960	4.955
10,100	4.951	4.946	4.941	4.936	4.931	4.926	4.921	4.917	4.912	4.907
10,200	4.902	4.897	4.892	4.888	4.883	4.878	4.873	4.869	4.864	4.859
10,300	4.854	4.850	4.845	4.841	4.836	4.831	4.826	4.822	4.817	4.813
10,400	4.808	4.803	4.798	4.794	4.789	4.785	4.780	4.776	4.771	4.767
10,500	4.762	4.758	4.753	4.749	4.744	4.739	4.735	4.730	4.726	4.721
10,600	4.717	4.713	4.708	4.704	4.699	4.695	4.690	4.686	4.682	4.677
10,700	4.673	4.669	4.664	4.660	4.655	4.651	4.647	4.643	4.638	4.634
10,800	4.630	4.626	4.621	4.617	4.613	4.608	4.604	4.600	4.596	4.591
10,900	4.587	4.583	4.579	4.575	4.570	4.566	4.562	4.558	4.554	4.550
11,000	4.545	4.541	4.537	4.533	4.529	4.525	4.521	4.517	4.513	4.509
11,100	4.505	4.501	4.496	4.492	4.488	4.484	4.480	4.476	4.472	4.468
11,200	4.464	4.460	4.456	4.452	4.448	4.444	4.440	4.436	4.433	4.429
11,300	4.425	4.421	4.417	4.413	4.409	4.405	4.401	4.398	4.394	4.390
11,400	4.386	4.482	4.378	4.375	4.371	4.367	4.363	4.359	4.355	4.352
11,500	4.348	4.344	4.340	4.337	4.333	4.329	4.325	4.322	4.318	4.314
11,600	4.310	4.307	4.303	4.299	4.295	4.292	4.288	4.284	4.281	4.277
11,700	4.274	4.270	4.266	4.263	4.259	4.255	4.252	4.248	4.244	4.241
11,800	4.237	4.234	4.230	4.227	4.223	4.219	4.216	4.212	4.209	4.205
11,900	4.202	4.199	4.195	4.192	4.188	4.184	4.181	4.177	4.174	4.170
12,000	4.167	4.164	4.160	4.157	4.153	4.149	4.146	4.143	4.139	4.136
12,100	4.132	4.129	4.125	4.122	4.119	4.115	4.112	4.108	4.105	4.102
12,200	4.098	4.095	4.092	4.089	4.085	4.082	4.078	4.075	4.072	4.068
12,300	4.065	4.062	4.058	4.055	4.052	4.049	4.045	4.042	4.039	4.036
12,400	4.032	4.029	4.026	4.023	4.019	4.016	4.013	4.010	4.006	4.003
12,500	4.000	3.997	3.994	3.991	3.987	3.984	3.981	3.978	3.975	3.971
12,600	3.968	3.965	3.962	3.959	3.956	3.953	3.950	3.946	3.943	3.940
12,700	3.937	3.934	3.931	3.928	3.925	3.922	3.918	3.915	3.912	3.909
12,800	3.906	3.903	3.900	3.897	3.894	3.891	3.888	3.885	3.882	3.879
12,900	3.876	3.873	3.870	3.867	3.864	3.861	3.858	3.855	3.852	3.849
13,000	3.846	3.843	3.840	3.837	3.834	3.831	3.828	3.826	3.823	3.820
13,100	3.817	3.814	3.811	3.808	3.805	3.802	3.799	3.797	3.794	3.791
13,200	3.788	3.785	3.782	3.779	3.776	3.774	3.771	3.768	3.765	3.762
13,300	3.759	3.757	3.754	3.751	3.748	3.745	3.743	3.740	3.737	3.734
13,400	3.731	3.729	3.726	3.723	3.720	3.717	3.715	3.712	3.709	3.706
13,500	3.704	3.701	3.698	3.696	3.693	3.690	3.687	3.685	3.682	3.679
13,600	3.676	3.674	3.671	3.668	3.666	3.663	3.660	3.658	3.655	3.652
13,700	3.650	3.647	3.644	3.642	3.639	3.636	3.634	3.631	3.628	3.626
13,800	3.623	3.621	3.618	3.615	3.613	3.610	3.608	3.605	3.602	3.600
13,900	3.597	3.595	3.592	3.589	3.587	3.584	3.582	3.579	3.577	3.574
14,000	3.571	3.569	3.566	3.564	3.561	3.559	3.556	3.554	3.551	3.549
14,100	3.546	3.544	3.541	3.539	3.536	3.534	3.531	3.529	3.526	3.524
14,200	3.521	3.519	3.516	3.514	3.511	3.509	3.506	3.504	3.501	3.499
14,300	3.497	3.494	3.492	3.489	3.487	3.484	3.482	3.479	3.477	3.475
14,400	3.472	3.470	3.468	3.465	3.463	3.460	3.458	3.455	3.453	3.451
14,500	3.448	3.446	3.444	3.441	3.439	3.436	3.434	3.432	3.429	3.427
14,600	3.425	3.422	3.420	3.418	3.415	3.413	3.411	3.408	3.406	3.404
14,700	3.401	3.399	3.397	3.394	3.392	3.390	3.388	3.385	3.383	3.381
14,800	3.378	3.376	3.374	3.372	3.369	3.367	3.365	3.362	3.360	3.358
14,900	3.356	3.353	3.351	3.349	3.347	3.344	3.342	3.340	3.338	3.336
15,000	3.333	3.331	3.329	3.327	3.324	3.322	3.320	3.318	3.316	3.313

IN BUYING COAL, the purchaser must secure the coal best suited and most economical for his combustion equipment. Boiler manufacturers design and guarantee their boilers, boiler settings, furnace volumes, draft equipment, and so on, for a certain kind of coal; hence it is of uppermost importance, for good efficiency, to use that coal. This is not necessarily the cheapest coal. It is that coal for which the furnace was designed, but this point is very much ignored by the average coal buyer.

Cost per ton of coal is only relative for purpose of sale, but the cots per million Btu is the actual cost (heat or calorific value); therefore, all coal cost should be on a MILLION BTU basis.

Knowing the kind of coal required and available, the cost per million Btu can then be determined from the cost per ton delivered to the bunker, or as fired, by using values given in Table I.

Importance of Sulphur and Ash

The sulphur content should be closely watched, since sulphur has very little heat value but may cause slagging and clinkering. It should be remembered that coal high in sulphur clinkers readily.

Another very important item is the ash, its amount, fusibility, and tendency to clinker. The ash fusion temperature varies from 1950 to 2950 F for different coals. Standard practice divides the fusing temperatures in three groups as follows:

a. Above 2600 F is considered refractory.
b. From 2600 to 2200 F is medium fusibility.
c. Below 2000 F is considered easily fusible.

Coal with ash at a fusion temperature of 2500 F or over causes very little clinkering, but coal high in sulphur and an ash fusion temperature much below 2500 F may clinker readily. This points to the fact that the fusing temperature of ash is very important, especially with a high CO_2 (low excess air) and high furnace temperatures. A high ash content reduces the calorific value of the coal, increases the cost of handling and disposal, and lowers the steam plant capacity.

With numerous coal receipts of different analyses, it is necessary to calculate the average or mean values of moisture, ash and Btu. This has always been a difficult problem; hence, a tabulation with an example will show the correct application.

The calorific value of the fuel (Btu per pound) might be given on 3 bases; as *fired*, *dry*, or *combustible*. A complete example has been given to explain the methods for conversion.

In analyzing coal, it is impossible to get the Btu values much closer than the values given in the table advancing by 10 Btu per lb. Whatever the cost per ton is, the table gives the correct value for 2 decimals, which is accurate enough for all commercial calculation.

How to Calculate the Correct Average Btu per Pound, and the Average Moisture, Ash, Volatile Matter, and Fixed Carbon in Per Cent

With monthly boiler operating reports and monthly coal invoices, it is often required to get the average Btu value per pound, the average per cent of moisture and ash for the month. The correct solution to a practical problem, set up in Table II, will explain this.

Kent; Mechanical Engineers Handbook, 12th Ed.; John Wiley & Sons, Inc.
Marks; Mechanical Engineers Handbook, 4th Ed.; McGraw-Hill Book Co.
MacNaughton; "Elementary Steam Power Engineering," 3rd Ed.; John Wiley & Sons, Inc.
U. S. Bureau of Mines, numerous bulletins.

A Review for Old-Timers — A Must for Young-Timers

The average is: $\frac{\text{Total Btu}}{\text{Total Lb}} = \frac{\text{Item C}}{32}$

$= \frac{392.850}{32} = 12,277$ Btu per lb.

It is not the sum of Item B ÷ 5, which gives 12,120 Btu per lb.

Table II is an excellent set-up; it shows clearly all items involved, provides a quick check without loss of time, and is very simple and easy to learn.

What Proximate Analysis Means

In the Proximate Analysis of coal, as received or as fired, five determinations are usually made:

Moisture, Volatile Matter, Fixed Carbon, Ash and Sulphur.

Each item is expressed in per cent by weight. The sum of the first four is taken as 100 per cent, while the sulphur is determined separately.

With dry coal, the moisture has been removed and the three remaining items — namely, Volatile Matter, Fixed Carbon and Ash — are then taken as 100 per cent. This is shown in Table III.

The Combustible of a coal consists of Volatile Matter and Fixed Carbon, and these 2 items are then considered as 100 per cent. See tabulation. (Data in the previous example will be used for this explanation.)

The per cent of Volatile Matter in dry coal is 27.87 ÷ 0.9487 or 29.38 per cent.

Per cent of Volatile Matter in combustible is 27.87 ÷ 0.8616 or 32.35 per cent.

The Fixed Carbon and Ash must be figured in the same manner to get the values on the dry basis. Moisture and ash cancel out under combustible.

Table IV lists a few coals to show the effect of moisture and ash by per cent in weight on the Btu value of a pound of coal by the Proximate Analysis.

Table II. Right and wrong methods of calculating average Btu per lb, moisture, ash and other constituents of coal when expressed in per cent

A	B	C	D	E	F	G
Pounds Coal	Btu per lb	A × B	Per cent Moisture	A × D	Per cent Ash	A × F
2	11,800	23,600	6.40	12.80	9.0	18.0
4	12,000	48,000	6.30	25.20	8.5	34.0
5	12,050	60,250	6.00	30.00	8.0	40.0
8	12,150	97,200	5.50	44.00	7.5	60.0
13	12,600	163,800	5.00	65.00	7.0	91.0
32	60,600	392,850	29.20	177.00	40.0	243.0
÷ 5 items (wrong)	12,120 Wrong		5.84 Wrong		8.0 Wrong	
÷ 32 lb (correct)		12,277 Correct		5.53 Correct		7.59

Example to Show Use of Tabular Values

Comparison in Heat Value of Coal A at $7 per ton with Coal B at $6 per ton

More coal of B must be fired to equal the heat value per pound of coal A. The multiplier is 12,247 ÷ 9,940 or 1.2321, which means that 1.2321 lb of coal B must be consumed for each pound of coal A. (Ratio is 1.2321 : 1) For moisture it is 0.16 × 1.2321 or 0.1971 lb in coal B against 0.0972 lb in coal A; a ratio of 2.03 : 1.0. For ash it is 0.1377 × 1.2321 or 0.1697 lb in coal B against 0.0443 in A; a ratio of 3.83 : 1.0. This shows conclusively that, for the same Btu demand, the equipment must handle twice the amount of moisture and 3.83 times the amount of ash by using coal B. Cost of coal A at $7 per ton is 4.083 × 7 or 28.58 cents per million Btu. Cost of coal B at $6 per ton is 5.030 × 6 or 30.18 cents per million Btu. Based on the heat value alone the cost of coal B is 5.6 per cent higher than coal A; this does not include such factors as effect of moisture on grindability, extra coal and ash to be handled, etc. If a steam power plant is designed for coal A to produce 100,000 lb of steam per hour at maximum efficiency, it can readily be seen that, by using coal B the whole design has to be larger to produce the same amount of steam. It requires more stoker area, more furnace volume, more forced draft fan capacity, more ash handling; in fact, everything costlier. Burning coal B with equipment designed for coal A reduces the plant capacity by about 30 per cent or 30,000 lb, so that only 70,000 lb of steam per hour are produced, the plant operation is inefficient and uneconomical.

The reverse is also true; to burn coal A in a boiler designed for coal B is not economical because the equipment is not tailor made for coal A. THIS IS IMPORTANT.

Table III. Various data on coal from Proximate Analysis

	As fired	Dry	Combustible
Vol. M.	27.87	29.38	32.35
Fix. C.	58.29	61.44	67.65
Ash	8.71	9.18	.....
Moist.	5.13	.....	.....
	100.00	100.00	100.00

1.0000 − 0.0513 = 0.9487 the divisor

1.0000 − 0.0871 = 0.8616 the divisor

Table IV. Effect of moisture and ash by per cent in weight on Btu per lb value of coal, from Proximate Analysis

Coal No.	Proximate Analysis: Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Btu per Pound: As Fired	Dry
1	2.86	33.23	58.08	5.83	14,105	14,521
2	3.50	37.98	51.08	7.44	13,286	13,770
"A" 3	9.72	32.44	53.41	4.43	12,247	13,567
4	9.93	33.13	48.77	8.17	11,896	13,208
5	11.93	29.99	43.90	14.18	10,303	11,699
"B" 6	16.00	32.41	37.82	13.77	9,940	11,833
7	16.91	26.85	38.87	17.37	9,524	11,462

*Derivation of Table I: One ton of coal weighs 2,000 lb. (short ton). One pound of coal has a heat value of 10,000 Btu, as fired.

Cost per ton is $1 or 100 cents, (unit price).

Heat value per ton is 2000 × 10,000 = 20,000,000 Btu at cost of $1 or 100 cents, (value in cents avoids zeros and reduces decimals).

Cost per million Btu is $\frac{100}{20,000,000} \times 1,000,000$ or 5.00 cents. Ans.

Example: The delivery price of coal containing 10,890 Btu per lb as fired was $6 per ton. What is the cost in cents per million Btu?

Value in table is 4.591; 4.591 × 6 is 27.546 cents or $0.27546. Ans.

Example: What is the cost per million Btu of a coal with a heat value of 13,525 Btu per lb (as fired) and at a cost of $7.10 per ton?

Value in table is 3.697, by interpolation between 3.698 and 3.696 and 3.697 × 7.10 is 26.25 cents or $0.2625 per million Btu. Ans.

There are three methods of reporting COAL ANALYSES:

	Bureau of Mines		A.S.M.E. Test Code
1. Coal	"as received"	or	"as fired"
2. Coal	"moisture free"	or	"dry"
3. Coal	"moisture and ash free"	or	"combustible"

Coal as **received**, as **fired**, or as **delivered**, is usually the condition of the coal as fed to the furnace from the bunker. It is this state on which the table has been calculated.

Very often the Btu per pound of dry coal or the Btu per pound of combustible is given.

Example: The Proximate Analysis of a pound of coal is: moisture 5.13%, volatile matter 27.87%, fixed carbon 58.29%, ash 8.71%, and a heat value of 12,800 Btu as fired. What is the heat value per pound of dry coal and per pound of combustible?

The percentage of dry coal is 100% — 5.13% moisture, or 94.87%.

and $\frac{12,800}{(100 - 5.13)} \times 100$ is 13,492 Btu per lb dry. Ans.

the combustible is (100% — % moisture — % ash) or (100 — 5.13 — 8.71) = 86.16%

and $\frac{12,800}{86.16} \times 100 = 14,856$ Btu per lb combustible. Ans.

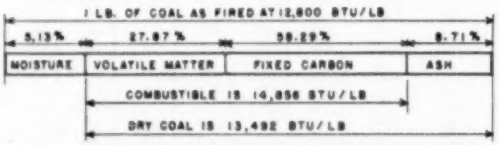


Diagram showing Proximate Analysis of coal and how Btu are determined by three methods

Basic Power Plant FIGURING

Correction: Engineering Constants

October issue, pages 82-84

In the October table of Engineering Constants, two errors got through our proof-reading and checking procedure. Mr. Engelman's copy was correct. Please mark your copy to show the following corrected values on page 84:

63,025 is 33,000 × 12 ÷ (2 × 3.1416)

0.9480 is 2,656,000 ÷ (60 × 60 × 778.26)

In some way the parentheses in these two calculations sneaked into the wrong places. We are very red-faced about this, especially because the use of these constants is intended to promote accuracy in figuring.

WHAT CAUSED THE BOILER EXPLOSION?

By H. B. McDERMID

DURING the working day of a very small crew of a little plant in the Middle west that had been established for the purpose of processing a new brand of stock feed, a small internally-fired, vertical, tubular boiler blew up with astonishing destructive results for so small a unit. An attendant who had just passed by the unit before the explosion said that the water glass showed nearly full. The fire was moderate, and the steam gage showed but 85 lb pressure, some five minutes before the 30 in. by 6 ft boiler blew to its destruction. As the boiler was at first used only for mild heating, the owners were much puzzled as to the cause of the explosion.

On arriving at the scene, the writer found the boiler had been installed in the basement of the building and had left its bottom end sheet behind, lying quietly on the foundation on which it had been placed, with very little damage evident in the lower surroundings. But above, the damage was enormous for so small a unit. The plant had been built with wooden floors back in the days when timber was both cheap and easy to get. The floor joists were rated 2 in. by 12 in., but were full 12 in. in depth, and nearly 3 in. thick; this dimensioning held for the joists on the first and second floors, while the roof rafters were nearly as heavy. The boiler had soared up like a rocket, and tore holes through all three obstructions at least 20 ft square, and eye witnesses said it sailed above the roof a good 200 ft, and came to rest about an equal distance from the foundation. No person was even scratched in the accident, everyone being out of the path of flight at the time.

Examination showed no evidence of overheating on the shell, but it did show startling evidence of misconstruction. In neither the state in which the unit was installed, nor the one from which it came, were there at the time any engineer's or firemen's license laws; nor were there any enforced laws about boiler construction or inspection. The history of the case seemed to be that the owners had taken an old boiler that looked pretty good to them and had a new plate welded on the bottom end of the shell by a local blacksmith, who had an acetylene torch and an obliging disposition, but who knew nothing about boilers, except they had to be water and steam tight.

He got that result all right, but some of his welded joints were paper thin and utterly incapable of holding pressure for long. The plate stood the strain for as long as it could, and then simply dropped off, and the shell sailed away, exactly like a V-2 rocket, smashing the building in its path but luckily no one was in its way. The destruction was much greater than any but an expert could imagine from such a small boiler, but was evidently greatly augmented by the comparatively large amount of hot water that of course flashed into steam the instant its pressure was released.

The incident serves to point the need for keen and careful supervision at all times of even small steam boilers, which in all sizes can be excellent servants, but once allowed to get out of proper control, can be mighty bad masters.

Questions and Answers

Q & A—THE POWER ENGINEER'S FORUM—HERE'S HOW IT WORKS

YOUR QUESTION about some problem in operation, maintenance or design will be published, signed only with your initials.

Answers to your question from other readers will be sent you as soon as received, then published as space permits, so that all may have the information.

You, too, answer questions from other engineers in the same way. You get paid well for published answers and also get the credit for knowing them.

If other engineers help you solve your problem, you express your thanks, via the Q & A editor.

Simple, isn't it? And effective! Just ask engineers who have tried it!

Question No. 475

HOW SHOULD HE FIGURE STEAM ENGINE STRESSES?

WHAT ARE the stresses on the crank pin and wrist pin in this steam engine?

Throttle steam pressure	150 psig
Engine horsepower	500
Stroke	24 in.
Bore	20 in.
Diameter of piston rod	4 in.

Will Q & A readers please show me the formulas by which these stresses can be figured, and how to put the correct values in them?

Metuchen, N. J.

G. J. T.

Answer No. 468

WHAT IS RATE OF CONDENSATION PER SQUARE FOOT OF STEAM COIL?

V.L.G. does not state the material from which the coils are made. He has (roughly) a temperature difference of 300 F between water at 60 F surrounding the coils and approximately 358.4 F (temperature of steam) inside of coil.

Condensation per square foot of heating surface for the above condition is as follows:

Wrought-Iron Coils	—	110 lb per sq ft
Brass	"	165 " " " "
Copper	"	190 " " " "

Hyde Park, Mass.

HERBERT W. BRANDT

Answer No. 471

SHOULD THE SUCTION PRESSURE COME DOWN TO ZERO ON THIS CO_2 COMPRESSOR?

ON HIS 120-ton CO_2 compressor, said E. B., September issue, here's what occurs. Operating pressures; suction 450 psi, discharge 950 psi.

a. On shutting down, close expansion valve, suction pressure comes down to 200 psi; close suction valve, suction pressure down to 100.
b. Close discharge valve, suction pressure goes up to 350 psi and discharge pressure comes down to 350 psi.

c. With machine shut down, suction and discharge pressures equalize and rise to 700 psi.

Why? Also, why does the compressor have to be barred over on center to start it? The compressor is driven by a 327-hp synchronous motor. Sometimes the fuses blow.

In the November issue, Fred Whyte said he thought the suction pressure should come down to zero if all valves were holding, and commented on the other points.

Here's more comment from John Gorrie.

Gorrie Agrees Valves Are Faulty

IN SHUTTING down a CO_2 compressor, the suction and discharge valves only should be closed. There is no necessity of closing the expansion (or regulator) valve. The gages will then equalize. There is no reason for the suction gage coming down to zero. Both gages should indicate alike when the machine is stopped.

To test the working of a CO_2 compression system: Close the expansion valve and pump down the evaporator gage from, say, 370 psi to 75 psi. If more than 200 revolutions are required to produce this result, either the suction and discharge valves or the expansion valve are defective.

It would appear that the valves mentioned by EB are faulty. There may be foreign matter in the system, and this causes an irregular action of the evaporator gage.

The brine in the evaporator should be warmed up to around 150 F; then, with all CO_2 valves open, the machine should be run. Close expansion valve and pump gas over to the condenser, then open expansion valve, and allow gas to rush into evaporator. **Repeat** this several times, opening valve at separator to blow off impurities with the gas.

A half pint of spirits of wine has been used in compressors to overcome excessive oil in compressors. Open up the compressor to pour in the spirits; then, on closing up, run the compressor, and drain frequently at the separator.

E. B. should look to his brine tanks and see that they are fully submerged.

Cooling water temperatures are all right.

In many cases, it is customary to bar 'round electric and steam driven CO_2 compressors before starting, but I cannot see why fuses blow, when starting up. What about relays or the breakers kicking out before the fuses blow? There is a possibility that E.B. has also electric trouble which should be looked into.

Lansing, Mich.

JOHN M. GORRIE

Help! Help! HELP THIS ENGINEER PLAN A POWER PLANT LABORATORY

THE POWER PLANT ENGINEER for one of our most important industrial companies has been handed the job of planning a complete set of testing and laboratory equipment for a new power plant being built for one of the subsidiaries of his company. He has been a subscriber to and reader of, this magazine ever since 1926 and now he is asking Q & A readers to advise him on the design and equipment of such a laboratory.

The laboratory would be primarily for testing boiler feedwater and lubricating oil. In this particular new power plant, all steam will be generated in waste heat boilers installed behind reverberatory furnaces. No direct-fuel-fired boilers will be installed. Analysis of waste heat gas will be made by the furnace operating staff, hence this laboratory will not require gas testing equipment.

The power plant will include condensing turbine generators, deaerating feedwater heaters, evaporator feed heaters and evaporators, converter air blowers and air compressors, also auxiliary pumps and accessories for all the above.

Now, our reader needs to know what tests should be made and, in detail, just what laboratory equipment should be installed for such a plant. He needs to know something about how the laboratory should be laid out and, if possible, some estimate of what it would cost to equip it. IMPORTANT: — He does not want the testing details (those are readily available) but rather the equipment and layout for making them.

So come on, you power engineers who have good laboratories. Tell him! Or perhaps you have some definite ideas about what you would do if you could build a completely new and up-to-date laboratory from scratch, as in this case.

Let's have 'em! — in the form of letters, detailed articles, sketches, estimates of equipment costs. Of course, you'll get a check for any of your ideas we publish.

Here's a subject on which every reader can use some information.

Every power plant must, in some way, test boiler feedwater; must make or have others make tests of fuel, flue gas analysis; take samples of fuel, steam, water; often calibrate and repair meters. Various combinations of these or all of them are carried out in power plant laboratories. So let's all put our knowledge into the pool and help our reader get the best laboratory for his particular plant.

Answer No. 473

WILL THIS SHUNT-WOUND GENERATOR FIT HIS CONDITIONS?

IN HIS INDUSTRIAL plant, said J. B., October issue, all process machinery is driven by d-c motors for speed control. Most of the direct-current for these is generated in their own power plant by 5 steam-engine-driven flat-compounded d-c generating units, totaling 2000 kw capacity.

Any deficiency of d-c power is made up by purchasing a-c power from the utility and converting it to d-c by motor-generator sets, which also have flat-compounded generators.

Now they have a chance to purchase, at a very low price, an unused second-hand steam-turbine-generator set of 500 kw, with a d-c shunt generator. This would give them needed exhaust steam for process, plus additional needed d-c power.

But can they operate that shunt-generator in parallel with the existing flat-compounded generators? If so, what type voltage regulator will they need to use?

Suggestions from Von Dannenberg

DETAILS given are too general to permit a definite reply to be given. Since the existing equipment is made up of generators which are "flat-compounded," the voltage of these units will probably rise slightly between the no-load conditions. Therefore a shunt-wound generator will probably not parallel satisfactorily with the existing units, since it has a definitely drooping voltage characteristic from no-load to full load.

It may be possible, however, if the shunt unit has suitable field characteristics, to provide it with a rheostatic type of voltage regulator, readily available from a number of manufacturers, which will enable the desired share of the load to be taken and allow the turbine to provide the required volume of process extraction and exhaust steam.

It is assumed the existing engine-generator and motor-generator sets are paralleling satisfactorily. So, to be certain of future economical operation, a complete review of the electrical characteristics should be carefully made.

From past experience, for similar conditions, regulating details have been provided to make such a turbine-generator carry a fairly constant load and permit "compound-wound" units to handle the load swings. Regulators can be provided to provide for such operating conditions.

It might be possible to have the turbine generator changed to a compound-wound unit by the manufacturer, and this expense ought at least to be considered, in view of its relation to future satisfactory operating conditions. The generator manufacturer can give the desired information at once about its operation in relation to the co-ordinated conditions.

Brooklyn, N. Y.

C. O. VON DANNENBERG

Prevent Return Line Corrosion

with

FILMING AMINES*

HERE'S AN exciting new development in the Water Conditioning Field!

Corrosion of steam and condensate return lines is a serious problem to most industrial plants. Such corrosion is caused by the presence of carbon dioxide and oxygen. Up to now, it has been the usual practice to neutralize the carbon dioxide. However, the high cost of this neutralization method has limited its application. And, no protection against oxygen corrosion is assured.

Betz Laboratories have developed a new, advanced process for the prevention of return line corrosion employing *octadecylamine*. This material *does not* neutralize the carbon dioxide. Instead, the amine is adsorbed on the metal surfaces in a monomolecular non-wettable film which acts as a barrier between the metal and the condensate, protecting against both oxygen and carbon dioxide attack. The monomolecular film does not increase in thickness with continued treatment. Results? As high as *99 percent reduction* in corrosion rate has been achieved!

Let a Betz Field Engineer show how you can cut costs in your plant with the use of filming amines. Write today! There's no obligation, of course. W. H. & L. D. BETZ, Gillingham & Worth Sts., Philadelphia 24, Pa. In Canada: BETZ Laboratories, Limited, Montreal 1.

Send for Betz Technical Paper #121, "How Filming Amines Prevent Steam and Return Line Corrosion".

*U. S. PATENT 2,460,259

BETZ

BOILER WATER CONDITIONING • COOLING WATER CONDITIONING • INDUSTRIAL WASTE TREATMENT

Answer No. 474

HOW CAN THEY STOP STACK EMISSIONS WHEN BURNING SAWDUST OR WASTE WOOD?

TYPICAL questions about this were asked by two readers in the October issue.

D.C.B. burns sawdust, fed to the boilers by a blower and collecting system and burned on grates.

H.L.C. burns both wood scrap and coal on a stoker.

Both get severe fly ash, spark and dust emissions, causing complaints from the neighbors and want to know what they can do to stop the trouble.

Our editorial note pointed out that if there was adequate combustion volume and proper supply of combustion air, especially overfire air, and if sufficient turbulence was produced in the combustion zone, then the fuel would be burned efficiently and a minimum amount would go out the stack.

The Dutch oven is often the answer to wood-burning problems. But in recent years, more study has been given to building the standard types of furnaces to burn wood properly. Yet, with existing boilers, the Dutch oven may be the only economical answer.

Other engineers agree with this very general comment; for example:

Needs More Combustion Space, Says Butcher

APPARENTLY D.C.B. is short of adequate combustion space under his boilers. If the combustion space is adequate, the fuel will be entirely burned before leaving the combustion chamber.

If headroom for the boilers is limited so they cannot be raised, it may be possible to add a Dutch oven to the furnace.

There is a new device known as a sonic agglomerator, which should be worth investigating where dust must be removed from the stack gas. It would not answer the problem of what to do with unburned fuel particles, but should do a good job of freeing the flue gas of dust particles too fine to be handled by ordinary cyclones.

Cincinnati, Ohio

IRA A. BUTCHER

A sonic device of this kind was described in *Chemical Engineering*, May 1950. See also: Where Will Utrasonics Fit in the Power Field; *Power Generation*, September 1948.

LETTERS TO THE EDITORS

(Continued from page 53)

four valve stands on the same line. See Fig. 1. This would leave a clear passage between the ends of the turbines and the turbine control boards for the entire length of the turbine room.

A 90-deg bevel-gear bracket was installed on the yoke of each valve, with a universal joint on the stub shaft, as shown in Fig. 2. From here, shafting led to a hinged joint at the lower end of the wheel shaft. Where slight changes of alignment occurred, universal joints were installed. Where noticeable angular changes of direction occurred, hinged joints in universal brackets were installed. In each length of shafting (excepting the handwheel shafts), one shaft coupling was of the expansion type to allow for changes in length under operating conditions.

Los Angeles, Calif.

HOWARD T. LIVINGSTON

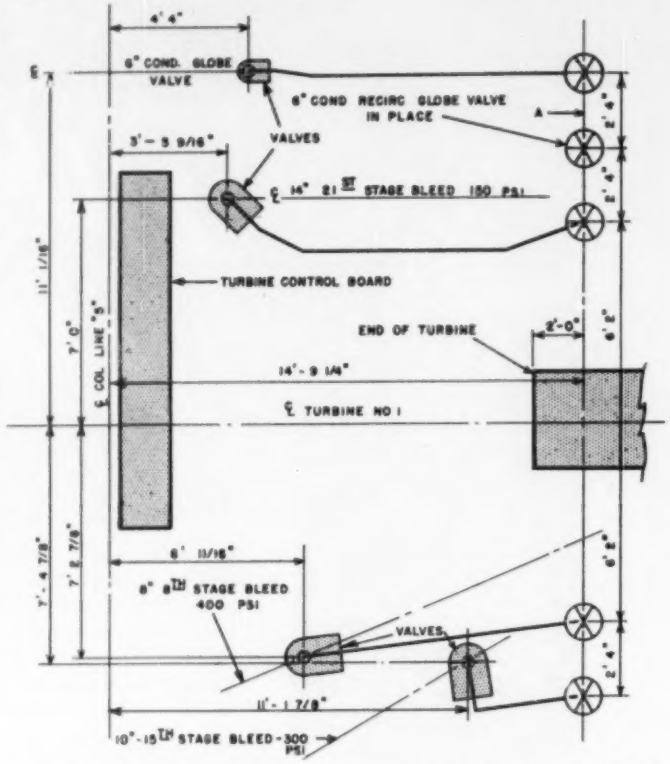


Fig. 1. General plan of turbine room floor at steam end of Turbine No. 1 as described by Livingston. It shows location of the valves and former floor stands and the way the extension shafts permitted the new location of all valve stands along line A. This cleared the stands out of the space between turbine and control board. The new floor stand arrangement will be standard for the entire plant when four new additional turbines are installed with shafts parallel to No. 1

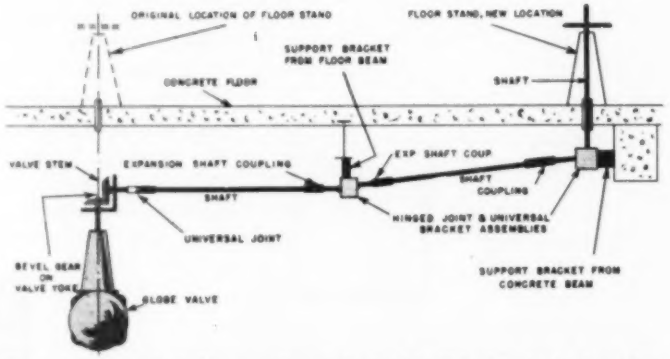
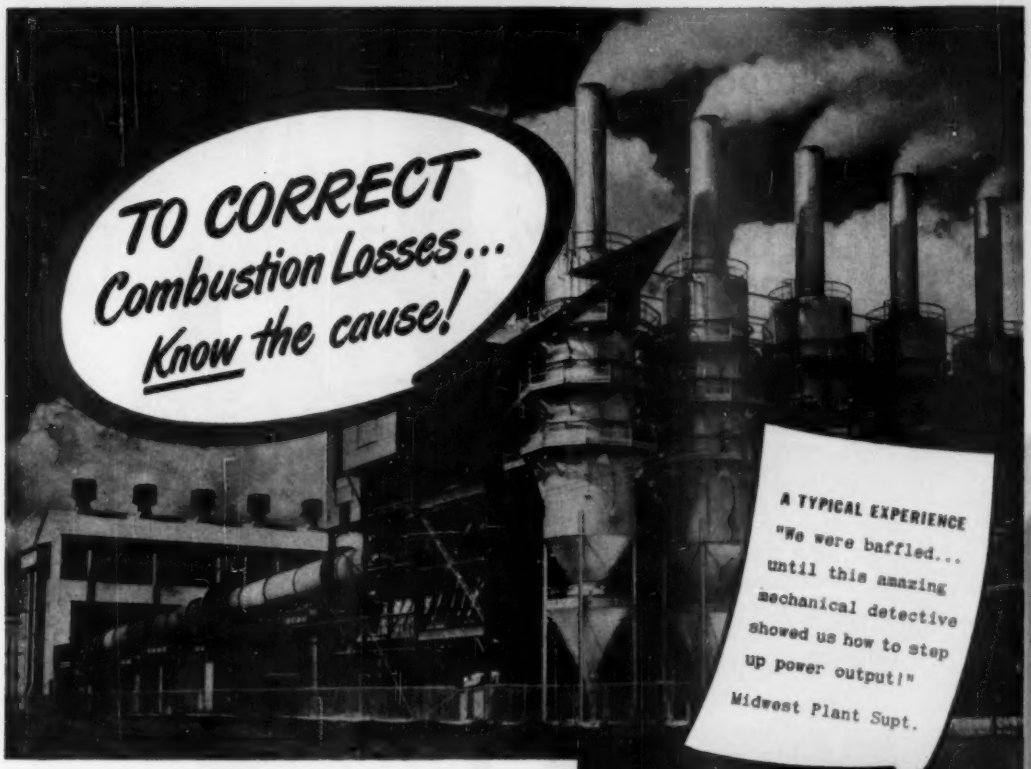


Fig. 2. Elevation under turbine room floor as described by Livingston, showing how valves were fitted with bevel gear and extension stems leading to new position of floor stand. All installation work done by plant mechanics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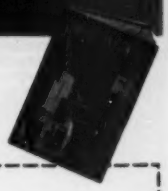

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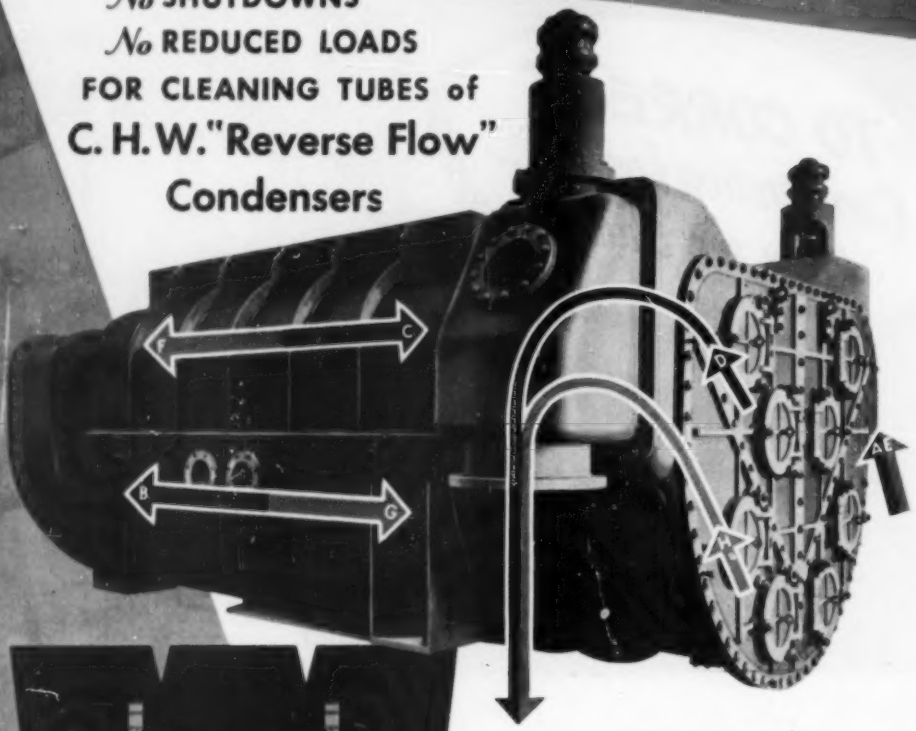

In the normal operation of a C. H. W. "Reverse Flow" Condenser, as shown in photograph, the lower half of the water inlet valve and the upper half of the discharge outlet valve are open and water follows path of black arrows (A-B-C-D). For flushing, these valves are closed, and the other valves opened, flow reverses, and water follows course indicated by gray arrows (E-F-G-H), as shown in side view. Note that piping in and from the water box is as simple as with a standard condenser.

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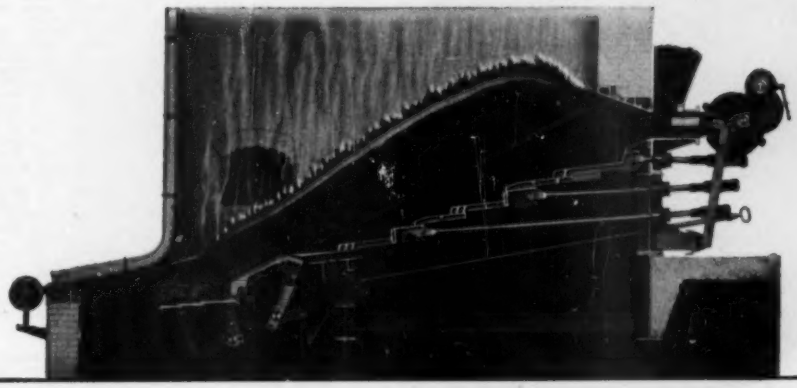

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New ENGINEERING BOOKS

Nuclear Physics by **Frances Bitter. First Edition;** 6 by 9 in.; 224 pages; illustrated; cloth; published by the Addison-Wesley Pres, Inc., Kendall Square Bldg., Cambridge 42, Mass.; 1950. Price $5.50

This new book has been written to give the non-specialist a clear understanding of the basic concepts and processes of the rapidly developing field of nuclear physics. The author assumes only a minimum background of technical knowledge on the part of the reader.

Engineers, biological scientists and educated laymen, will find in this book a clear exposition of this new fascinating field which is assuming more importance every day in their own work.

Where does nuclear energy come from? Why is nuclear energy completely different from the energy of chemical reactions? These and many other questions are discussed in detail. The presentation has been kept as simple as possible to make it easy for the reader to follow the main thread of the discussion. An up-to-date isotope chart is included at the end of the book. Some of the problems and exercises at the ends of chapters have been chosen with the intention of interesting students who may wish to think somewhat more deeply about matters discussed in the text. An idea of the contents of the book may be had from the following chapter headings: 1—The Evolution of Nuclear Physics; 2—Definitions and Prerequisites; 3—Protons, Electrons, and Quanta; 4— Neutrons, Neutrinos and Nuclei; 5— Rays and Beams; 6—Masses and Moments; 7—Radioactivity; 8—Nuclear Reactions; 9—The Consequences of Fission. This is a splendid book for anyone interested in any aspect of nuclear physics.

• • •

Pocket Encyclopedia of Atomic Energy edited by Frank Gaynor; first edition 5¾ by 8½ in.; 204 pages; cloth; published by the Philosophical Library, 15 E. 40th Street, New York, N. Y.; 1950. Price $7.50.

The purpose of this book is to present a comprehensive collection of brief explanations and definitions of concepts and terms in the field of Nuclear Physics and Atomic Energy. It is aimed at the scholar, researcher, teacher, librarian, student and intelligent layman. This book is not a textbook. As the author points out in the preface, it is merely a sort of tourist's guide in the new and strange realm of the atom. It is not an accurate detail map of this strange land, not meant to describe every hill and vale. It is intended to furnish the stranger on a brief excursion into this unknown land with a general bird's eye view, merely to point out to him the most outstanding landmarks and the main highways which will lead him to his goal—that is, to a general understanding of the atom, its nucleus, its energy, and relationship to human life and progress.

There are individual entries for every element indicating chemical symbol, group of the periodic table, name of the discoverer, date of discovery, atomic number, atomic weight, melting point, boiling point, specific gravity, stable isotopes, radio isotopes. Brief descriptions of the best known types of nuclear reactions are given. There is also an entry for every member of the known radioactive family. Furthermore, there are a great many brief and concise descriptions of subjects such as nuclear fission, tracer technique, atomic bombs, the H-bomb, etc. Finally, thumbnail biographical sketches of outstanding nuclear physicists and chemists give the reader a familiarity with the personalities involved with the field of nuclear science.

• • •

Giant Brains or Machines That Think by **Edmund C. Berkeley. First Edition;** 3½ by 8½ in.; 253 pages; cloth; published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York, New York; 1949. Price $4.00.

The subject of this book is a type of machine that comes closer to being a brain that thinks than any machine ever did before 1940. These new machines are sometimes called mechanical brains and sometimes sequence-controlled calculators and sometimes by other names. Essentially, though, they are machines that can handle information with great skill and great speed and that power is very similar to the power of the brain.

The author's purpose in writing this book is to tell enough about these machines so

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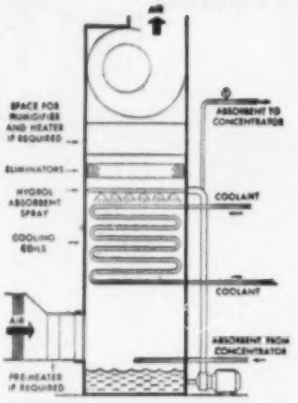

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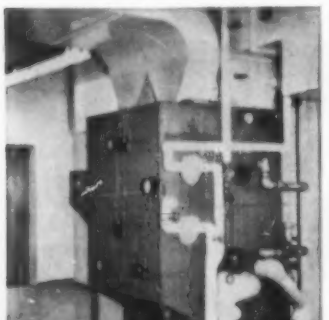
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that we can see in general how they work. He has sought to explain some giant brains that have been built and to show how they do the thinking operations. He has endeavored to talk about what these machines can do in the future and to judge their significance to us. As the author looks at it, these machines will take a load off men's minds as great as the load that printing took off men's writing.

The book, as the author points out, is intended for everyone. It is put together in such a way that any reader can select from it what he wants. Perhaps at first reading you will want only the main thread of the story, then read only what seems interesting and skip whatever seems uninteresting. Nearly all the chapters can be read with little reference to what goes before, although some reference to the supplements in the back may at times be useful.

Perhaps your memory of physics is dim. The little of knowledge of physics needed is explained here and there throughout the book and the index should tell where to find any explanation you may want. Perhaps it is a long time since you did any algebra, then supplement 2 on mathematics may hold something of use to you. Two section labeled as containing some mathematical details may be skipped with no great loss.

There are no photographs in Mr. Berkeley's book, although there are over 80 drawings. As the author indicates, photographs of these complicated machines can really show very little—panels, light switches, wires and other kinds of hardware. What is important is the way the machine works inside. This cannot be shown by a photograph but may be shown by schematic drawings.

On the whole, this is one of the best books on the subject for the general reader that we have ever seen and we recommend it very highly.

• • •

Sales Engineering by Bernard Lester; Second Edition; 226 pages; illustrated; size 6 by 9 in.; cloth binding; published by John Wiley & Sons, Inc., 440 Fourth Avenue, New York 16, N. Y. Price $3.00.

This book is one of the most informative and interesting we have read in a long time and, in fact, we have never read anything else just like it.

There are many books on sales work but we have seen few on sales engineering. Our observation has been that in sales engineering the successful man places most of the emphasis on engineering, although he still must use a good many of the methods of the salesman along with the engineering.

Perhaps the outstanding feature of the book to us is the fact that it tells in a very interesting way the things that sales engineers actually have to do in practice and that these described methods are the ones that are used by the sales engineers of our acquaintance.

Engineering skill has been associated largely only with design and production, yet the whole procedure of production depends upon orders from customers or a waiting market. In the last analysis the sales engineer is a designer and fabricator of orders and this often involves a high degree of technical knowledge and a knowledge of economy. The work of the sales engineer must not be confused with that of the more popular merchandising salesman.

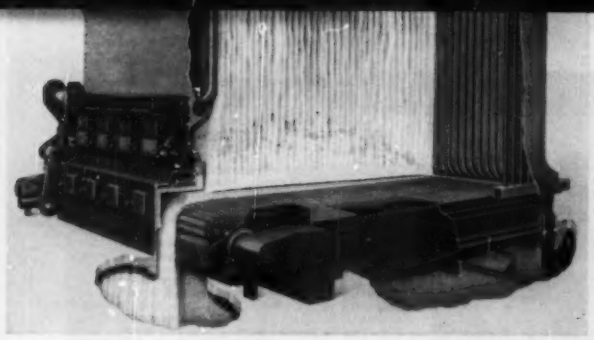
The book begins with a discussion of what sales engineering is, how it is affected by economic changes and points out that the sales engineer should have an increasing interest in world markets. Part II on Buying and Selling shows how important is the knowledge of the market, discusses motives in buying, existing systems of distribution, the individual purchaser and sales engineering principles.

Part III on the Sales Engineer in Action gets right down to cases and talks about the sales procedure, the sales interview, tools used in selling, group selling technique, meeting obstacles, selling each product, and the like.

Part IV covers Selling to Those Who Buy for Resale and Part V The Training and Development of the Sales Engineer.

The author is a veteran sales engineer himself and it is perfectly clear from his book that he has been through the mill himself. Here is information right from the horse's mouth. It should be particularly valuable to the undergraduate engineer or the young engineer just leaving college, or it indicates a field in which, if he has the aptitude and personal characteristics for it, he can capitalize on his engineering interest very effectively.

We heartily recommend this book, not only as an authoritative guide to the field



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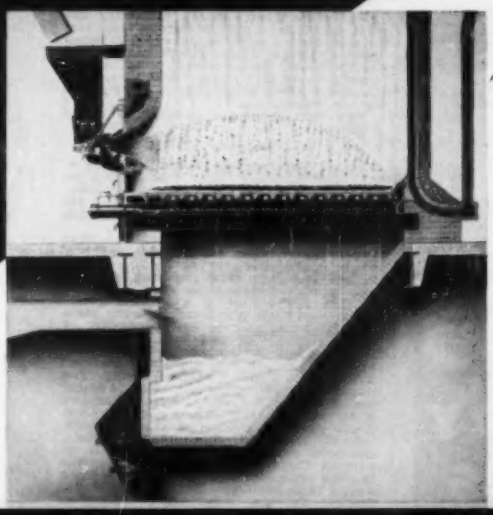

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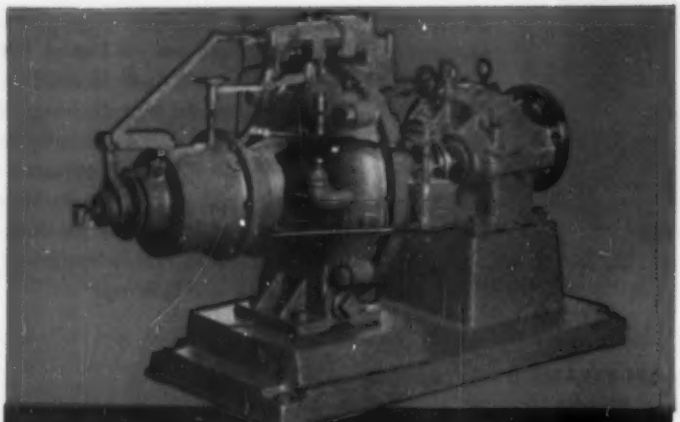

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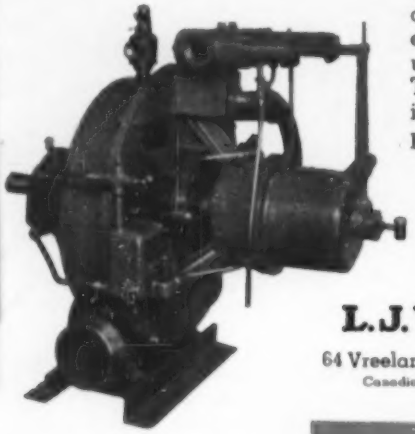
The use of turbines as an alternate source of auxiliary drive is good business in these days of urgent production and uncertain industrial conditions. When electric motor drive is subject to power failures due to strikes, fires, floods, hurricanes (or bomb attack), the ability to continue with steam auxiliaries is an advantage that is worth many times the cost of the alternate equipment. And the use of Wing Steam Turbines for such services as pumps, compressors, fans, blowers, generators, etc., can cut power costs by acting as a reducing valve on boiler steam for use in process and heating.



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of sales engineering, but also because it is so well written and obviously represents the work of a man who knows what he is talking about. Not all textbooks produce that impression.

• • •

Small Plant Management: Edited by Edward H. Hempel. Size 6 by 9 in.; 548 pp including index; cloth bound. Published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York 18, N. Y. Price $6.00.

Prepared under the auspices of the American Society of Mechanical Engineers, this book shows how small plants fit into the economic picture, how they are set up and operated, and the over-all opportunities for small plants both here and abroad.

As the title of the book implies, this treats the management end of a small plant, discussing such subjects as: financing and banking; top management planning; legal requirements; getting along with the union; how to get best productivity; how to save in taxes; and so on.

Each of the twenty chapters is written by an expert in his special field. For any person contemplating operation of, or already operating, a small plant, this book should prove of great assistance. Comparing and applying the techniques and methods indicated in the book to your own management procedures will point the way to improved plant organization and output.

• • •

Handbook of Industrial Water Conditioning by W. H. & L. D. Betz; Third Edition; 200 pages; illustrated; size 8½ by 11 in.; fiber binding, published by W. H. & L. D. Betz, Gillingham and Worth Sts., Philadelphia 24, Pa. Price $2.00

Here is the Third Edition of this famous handbook, revised and brought up to date to incorporate changes in the field since the First Edition. It is a must for power engineers who have to deal with water treatment in industry.

The first chapters of the book deal with general water treatment practices, such as aeration, coagulation, softening by various methods, such as lime soda, zeolite, hot process phosphate. Filtration, chlorination and hydrogen sulfide removal are covered, also recarbonation and silica removal by magnesium salts and by demineralization. The latter chapters of the book deal with specific water problems such as boiler scale formation, slime and algae control, industrial waste treatment and the like. The book is written in the most practical manner, addressed primarily to the engineer rather than the chemist and is well illustrated with drawings and diagrams showing the construction and principles of operation of a great deal of the equipment he finds in practice. Chemical theory is interpreted in a very clear manner with very few chemical equations and where mathematical calculations are required, they are clearly explained. Many of the relations are shown by curves and charts.

A supplementary section of the handbook covers water analysis explaining use and applications of the various tests and restricting the methods discussed to those readily applied in field determinations and in the plant. The methods presented are chiefly those that readily lend themselves to the work of controlling the condition of the water.

Again this is a must book for the power engineer.

• • •

Steam Turbines and Their Cycles by J. Kenneth Salisbury. First Edition; 6¼ by 9¼ in.; 645 pages; illustrated; cloth; published by John Wiley & Sons, Inc., 440 Fourth Ave., New York, N. Y.; 1950. Price $9.00.

This is a most excellent book, one that should be of value and interest to every power plant engineer and also to designers and consulting engineers who design power systems. One reason for this is that the author is a practicing designer — a man who has had many years of experience in the actual design of steam turbines. In this book he presents the essentials of the design of steam turbines in a thoroughly digestible manner, devoid of unnecessary abstract theory. The result is a crystal clear treatment of steam turbines for the users and manufacturers of steam turbines, designers of power plant cycles and test engineers in power plants.

As Mr. Salisbury explains in his preface, the book is an outgrowth of a course he gave at Union College during World War II. The class consisted chiefly of graduate mechanical engineers from the General Electric Co. and surrounding industries. The course started with a review of fundamental thermodynamics and the flow of

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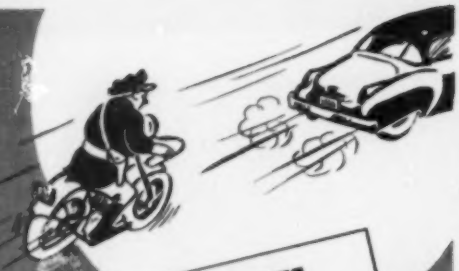

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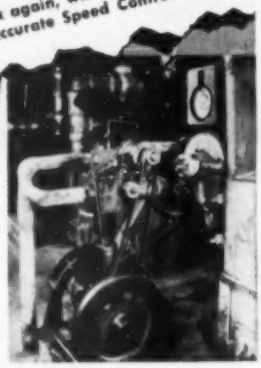

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fluids, stripped to the barest essentials to increase the rate at which information of immediate and practical value could be taught. Derivations were usually bypassed in favor of presenting results and a method for their use. Considerable time was devoted to an intensive skeleton course in design of steam turbines, with particular emphasis on facts of value to application engineers.

The necessary thermodynamics, cycle theory and flow of fluids background is presented early in the book with practical short-cut data of great value in daily design work. Data on steam, theoretical heat rates, and steam charts are included in the Appendix for ready reference.

The book is divided into 4 parts. Part I on Fundamentals of Turbine Design gives a review of fundamental thermodynamics, with practical short cut data never before published, of great value in daily design work. This is followed by material on external and internal characteristics of turbines, guarantees, correction factors, nozzle bucket design, exhaust loss and stage pressures. Part II, which takes up the Regenerative Cycle, discusses the effect of the major variables in the feedwater heating cycle on the heat rate of a steam power plant. Heat balance by conventional methods is presented by the use of examples and methods of checking results are given. Following this a short cut method of determining heat balance is offered, together with all the necessary curves and data required to use it. Part III deals with new cycle evaluation methods. Here is discussed the accurate calculation of losses in the feedwater heating cycle with little effort and the use of only simple arithmetic. The method permits direct correction from test to guarantee cycle, economic appraisal of proposed design changes in a given cycle and above all, provides a perspective never before possible of losses in feedwater heating systems. Part IV, the final section of the book, is devoted to Application data. These data permit quick approximation of all data commonly used in preliminary design work.

As indicated above, the price of the standard edition is $9.00, but a college edition is available at $7.50.

• • •

Falk's Graphical Solutions to 100,000 Practical Problems, prepared and edited by Karl H. Falk. Third Edition; 6½ by 9¼ in.; 419 pages; cloth; published by Columbia Graphs, Columbia, Conn.; 1950. Price $6.00.

This book is a collection of worked-out problems which have been solved by the graphical method. There is no text. Each page is a chart which represents an infinite number of solutions to one or more particular types of problems. The examples included have been chosen with the purpose of giving the book the widest possible range of practical application. Examples from mechanics, hydraulics, electricity, construction, physics, chemistry, agriculture, medicine, mensuration, measures and weights, have all been included, with the aim of giving the user a handy reference book of solved examples of the types of problems he is most likely to meet in his daily work. All graphs have been constructed so that only straight line connections are necessary. Each graph has been worked out to its most simplified form so that the diagram may be read with the utmost accuracy by persons not previously skilled in the reading of graphs.

Each page gives an example of the use of that page, shown clearly within dashed lines.

In addition to giving such engineering information as the required strength of a beam, torsional deflection of a shaft, linear expansion of steam pipe or the sag of a flexible cord, the book also gives information on such subjects as the temperature of various cities. If you want to know the average temperature of any city in the world, it is merely necessary to turn to the proper graph and read the correct answer right off the graph. Similarly it will give you the amount of gasoline necessary to drive a car from Miami to Los Angeles.

• • •

Transient Performance of Electric Power Systems by Reinhold Rudenberg; First Edition; 6½ by 9¼ in.; 833 pages; cloth; McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y.; 1950. Price $12.00.

The field of transient electric phenomena has developed through the decades into an important foundation of electrical engineering. Some of the accidental transient phenomena, like short circuits in a network, instability of the generating machinery and lightning disturbances on transmission lines, have become of such

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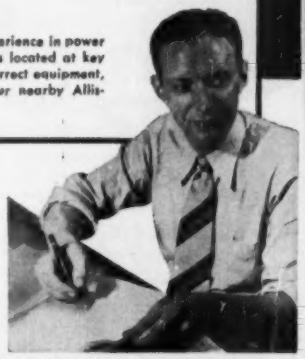

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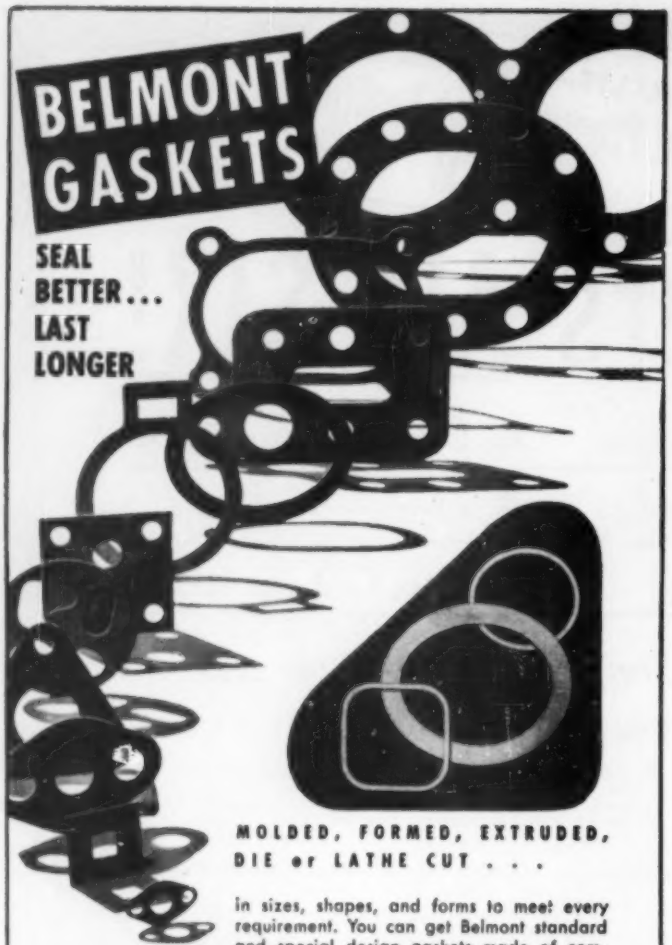

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outstanding importance as power systems have grown, that the layout of modern power systems is predominantly determined by these transient conditions.

This importance of transient phenomena is one reason why this book by Mr. Rudenberg is so important. From experience of more than 30 years as an engineer and still longer as a teacher, Dr. Rudenberg has learned that in the minds of students of engineering those methods of solution for intricate problems survive best which are of great possible simplicity. For this reason in this book the mathematical analysis is considered as an auxiliary tool. Every problem is directly attacked by a method expedient in that special instance, be it analytical for linear, or graphical for nonlinear examples. Thus a case system of analysis is developed for the treatment of transient problems.

This book is an enlarged edition in English of a classic German text. The material is arranged so that it progresses in all the main sections from the simpler to the more difficult. The topics treated correspond to parts of courses which the author has given on electric machinery, apparatus and instruments, power transmission and distribution, and transients proper during the last 12 years at Harvard University.

• • •

Fundamentals of AC Circuit Interruption by Dr. Erwin Salzer. Size 8½ by 11 in.; 56 pages; paper bound; published by Allis-Chalmers Mfg. Co., Milwaukee 1, Wisconsin. Price 40 cents.

This is a concise presentation of circuit closing and opening operations by Dr. Erwin Salzer, consulting engineer of the Allis-Chalmers Mfg. Co., presented in easy-to-grasp form. The booklet in substance is a reprint of a series of articles on Fundamentals of AC Circuit Interruption, published in the Allis-Chalmers Electrical Review of 1948 and 1949, and is written on the level of a college text on physics.

• • •

GE Manual of Instrument Transformers, Operation Principles and Application Information. 76 pages; paper covered; illustrated; published by the Apparatus Department, General Electric Co., Schenectady, N. Y. Price $1.00.

This profusely illustrated manual, covering the theory of operation and the application of instrument transformers is written for practicing engineers and students engaged in the fields of power generation, transmission and application where metering and relaying problems can be solved by the correct application of instrument transformers.

The manual covers the basic fundamentals of instrument transformers, such as accuracy standards, insulation and polarity. In addition, it gives complete information on potential and current transformers, including operating principles, types and ratings, applications, circuits, fusing, etc.

A chart for selecting the proper transformers for a specific application and a bibliography covering various phases of instrument transformer operation, design, application and performance also are included.

• • •

James Watt and the History of Steam Power by Ivor B. Hart. First Edition; 5¾ by 6½ in.; pages; cloth; published by Henry Schuman Inc., 20 E. 70th St., New York, N. Y.; 1949. Price $4.00.

While this book about James Watt and the steam engine was written for the general reader, every power engineer will also find it of considerable interest.

The book deals with more than a description of James Watt's mechanical inventions. Beginning with a short discussion of the main factors in human development from the age of instinct to the age of reason, the author proceeds to a review of the background to the life and the times of James Watt, the social, economic, cultural and scientific outlook of the seventeenth, eighteenth and nineteenth centuries. The story next turns to the work of those who preceded Watt as pioneers of the steam engine and so leads naturally to an account of Watt's own life and work.

Watt's work, of course, was the combination of centuries of speculation and experiment, from Leonardo da Vinci to the immediate predecessor of Watt, Thomas Newcomen. In this book Dr. Hart reviews the roles of all the pioneers whose hypotheses and inventions laid the groundwork for Watt's dramatic success.

Dr. Ivor B. Hart, who wrote this book, was educated at Queen Mary College and University College of London University,

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CHROME-MOLY STEAM VALVES

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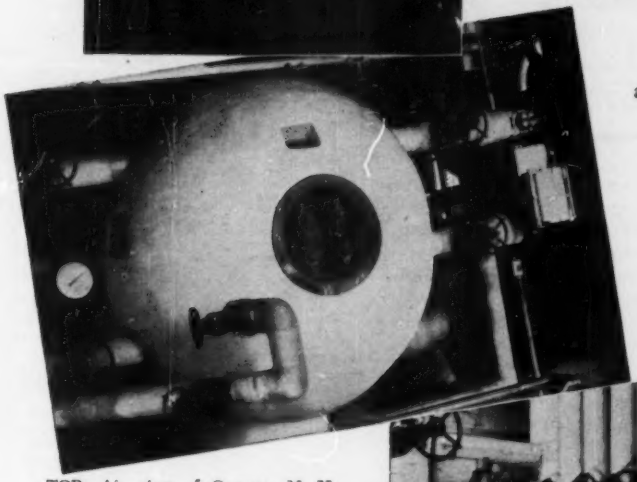

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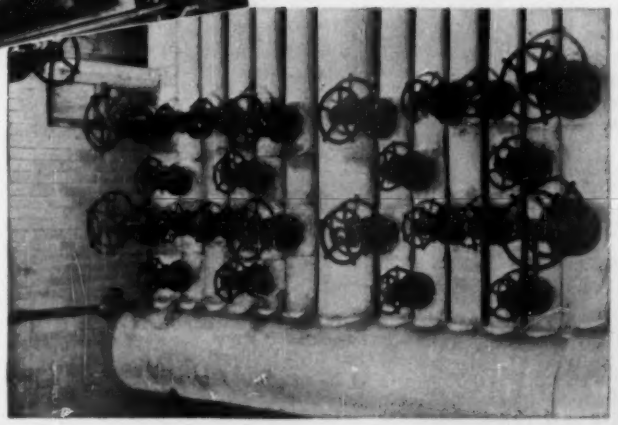

TOP: Air view of Oswego, N. Y, Station of Niagara Mohawk Power Co.

CENTER: Valves on main drum of 875,000 pounds per hour steam generator.

RIGHT: Drains from main steam, attemperator, and superheater lines employ a maze of valves.

NEW CATALOG F-9

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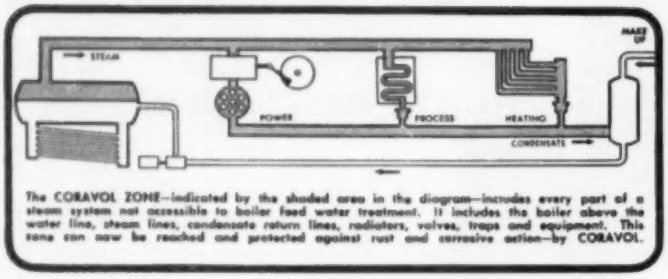

The CORAVOL ZONE—indicated by the shaded area in the diagram—includes every part of a steam system not accessible to boiler feed water treatment. It includes the boiler above the water line, steam lines, condensate return lines, radiators, valves, traps and equipment. This zone can now be reached and protected against rust and corrosive action—by CORAVOL.

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CORAVOL, the original* amine process, has the flexibility that lets it conform to each individual need. The **CORAVOL** you will use is formulated to do the best protective job under your own plant conditions.

*The use of **CORAVOL** in steam systems is covered by U. S. Patent No. 2053024. The Western Chemical Co., owner of this patent, grants licenses under which volatile AMINES purchased from other sources may be used in steam systems upon payment of royalty to Western Chemical Co.

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where he received his B.Sc. and Ph.D degrees. In addition to having written several textbooks in physical science, statics, heat and aeronautics, Dr. Hart is the author of Makers of Science, The Great Physicists, and The Great Engineers. He is a member of the Newcomen Society of Great Britain and the United States.

• • •

Handbook of Human Engineering Data for Design Engineers by the Handbook Staff of Tufts College, in co-operation with Technical Publications Division, Jackson & Moreland, Engineers. Technical Report — SDC 199-1-1; 400 pages; size 8½ by 11 in.; loose leaf binding; plastic cover; published by Tufts College, Medford, Mass., and available through Office of Technical Services, Department of Commerce, Washington 25, D. C. Price $5.00.

Up to the present time, says Rear Admiral Luis deFlorez, USNR, in a foreword to this book, we have been able to keep up with technological progress by education and training, but we have now reached a point where the machine has dwarfed the man, for the characteristics of the individual — the human machine — have not changed in the memory of man and will not change for countless generations to come, while the man-made engine is capable of ever increasing power, scope, and speed of operation. We must, therefore, consider man's capabilities as a constant in contrast to the unending progression of the machine.

The human faculties of perception, action, reaction, and decision can now be taxed to such an extent that it is no longer possible to take full advantage of the machine unless the control of the machine can be tailored to human capabilities. How can we do that? It is in an attempt to answer this question that this report has been issued. It is the first report on a study of human beings in relation to the machine. The book is intended for the design engineer and all others who deal with the inter-actions between men and machines. It is particularly important to get some information on these subjects to the people who design and build the machines that are operated by men, because original design characteristics limit what men can accomplish with machines. It is too often assumed that men can learn to do anything, but human beings, as control devices for machines, reach a point at which their human performance and sensitivity may break down. Machines of the future must be designed with these limitations in mind. Accordingly, the Tufts College Institute for Applied Experimental Psychology has begun a detailed study of human beings from the foregoing point of view to determine something about their characteristics, as those characteristics are related to machines.

The book is divided into the following parts: Part I — The Human Machine; Part II — The Human Body; Part III — Vision; Part IV — Audition; Part V — Skin Sensitivity and Proprioception; Part VI — Motor Responses; Part VII — Physiological Conditions as Determinants of Efficiency; and Part VIII — Intelligence.

In each part there is some discussion of basic concepts and the analysis of information resulting from tests on human beings in great detail. For example, under basic characteristics of vision, there is discussion of the human beings' sensitivity to light, his discrimination of brightness, his perception of depth and of color, his response to intermittent stimulation and his perception of motion.

Under motor responses, for example, there is discussion of reaction time, speed of movement, exertion of force and precision. That will give some idea of the scope and detailed treatment of the subject given in this book for the designer of any kind of machinery and the methods of controlling it. This study which is hoped will be a continuing one, should prove of primary importance. It is just a bare beginning in this field but it is a very good one and deserves the attention of everybody interested in the design of our modern machinery.

• • •

Introduction to the Transfer of Heat and Mass by E. R. G. Eckert. First Edition; 6¼ by 9 in.; 284 pages; cloth; published by McGraw-Hill Book Co., Inc., 330 W. 42nd St., New York, N. Y.; 1950. Price $4.00.

This translation and adaptation of the author's outstanding German text should be of special interest to mechanical and engineering students. It provides an understanding of the basic physical processes and the different modes of heat tranafer.

The evaporation and condensation of water vapor is used as the basis for the treatment of heat tranafer, and the book

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develops clear conceptions of the heat and mass exchange process. Through an understanding of these basic processes, the student or engineer will be able to use correctly the formulas for the calculations of heat exchanges and cooling problems.

The book endeavors to arouse and widen the understanding of the physical processes and laws connected with heat and mass transfer. This, however, is not possible without analysis. Therefore, formulas derive from analysis and proven by experiments are always preferred to relationships found by experiment alone. It is the opinion of the author that a physical process is understood thouroughly only where it is possible to calculate the occurrences from basic knowledge and when these calculated results are checked by experiments.

NEWS *from* THE FIELD

CHESTERFIELD PLANT TO HAVE FIRST PREFERRED STANDARD 90,000-kw UNIT

First 90,000/99,000-kw preferred standard turbine generator has been ordered, for installation in its Chesterfield Plant, by Virginia Electric & Power Co. It is scheduled for delivery in December 1951.

Recognizing the need for such a standard unit, the ASME special Standards Committee on Steam Turbine Generators has recently prepared final specifications for the turbine and as soon as generator specifications have been completed by the AIEE, a Joint Standard of AIEE-ASME will be issued.

The Vepco unit is designed for throttle presure of 1450 psi; 1000 F with reheat to 1000 F. The unit will by tandem-compound with double exhaust and with 5 extraction points.

The new generator voltage will be 14,400. The 90,000-kw rating is at 0.85 pf. The generator will have a guaranteed capability of 99,000-kw at 0.5 psig hydrogen pressure, 105,-882 kva, 0.8 short-circuit ratio; 121-764 kva at 15 psig; and 132,353 kva at 30 psig.

Austin C. Ross, manager of the Buffalo works of Worthington Pump and Machinery Corp., has been elected a vice president of that company at a recent meeting of the board of directors, according to an announcement today by H. C. Ramsey, president. Ross will continue to serve as Buffalo works manager, the announcement continued.

* * *

Third 150,000-kw unit has been ordered for Commonwealth Edison Co.'s Ridgeland electric generating station. The new unit is expected to be ready for service in the fall of 1953.

The company has decided to go ahead with its plans for this unit because of the increasing use of electricity in Chicago and Northern Illinois. The rising trend has been accelerated by the events of the past

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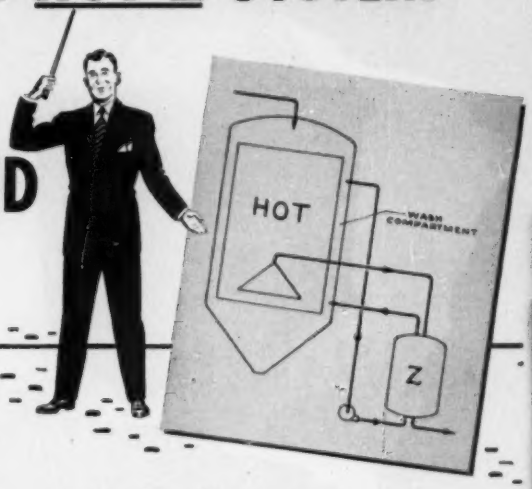


Choosing between Hot Process and Zeolite is no longer a boiler feed water problem. The Worthington Hot-Z System gives you the advantages of each system including deaeration.

SEE WHAT HOT-Z DOES FOR YOU:

1. Reduces hardness to 0.2 ppm without addition of excess soda alkalinity.
2. Operates on cheapest chemicals — lime and salt.
3. Saves enough in chemical costs to pay for average installation in 3 years.
4. Offers easy control when operating on variable waters.
5. Removes oxygen to 0.005 cc per litre.
6. Makes cumbersome two-tank lime-soda-phosphate systems obsolete.
7. Includes ideal facilities for the necessary hot clear water zeolite washing process.
8. Makes filters unnecessary except in special cases.
9. Does away with vent condenser scale.
10. Reduces phosphate precipitates in boiler to unobjectionable amount.
11. Reduces silica.

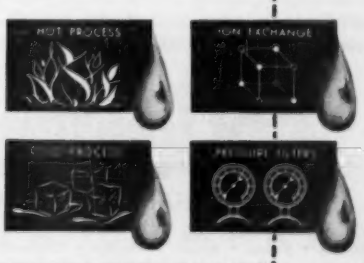
INVESTIGATE! If you are now considering split treatment, hold up your decision until you examine the Worthington Hot-Z System. Tell us your conditions of service and get our recommendation in terms of dollars and benefits. You'll find in our Hot-Z System, as in so much other equipment, *there's more worth in Worthington. Worthington Pump and Machinery Corporation, Water Treating Division, Dunellen, N. J.*

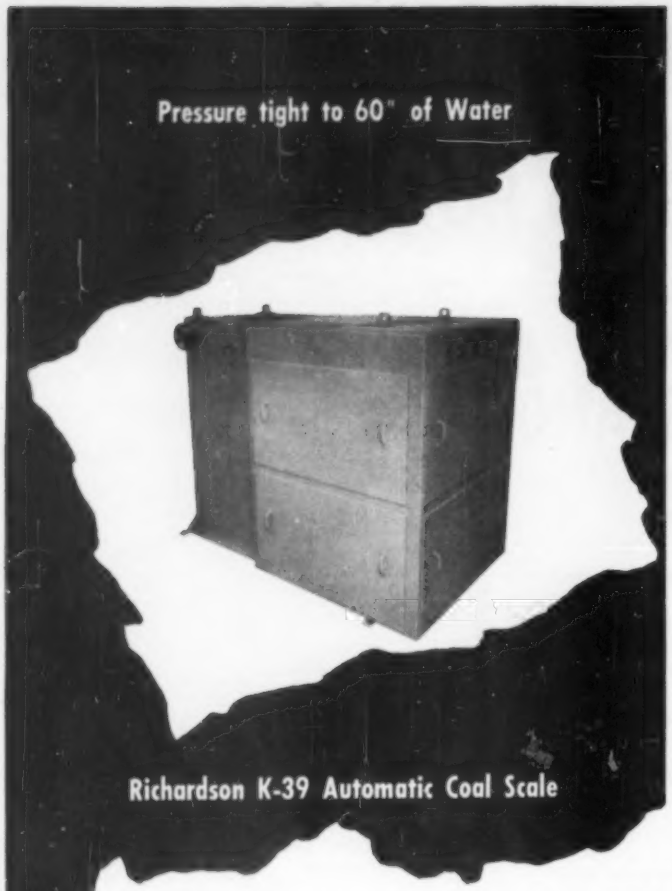
J0-2

WORTHINGTON

WATER CONDITIONING

Worthington Makes More of the Equipment for All Types of Water Conditioning Systems





The K-39 is the latest addition to the Richardson line of automatic coal scales that maintain a constant check of boiler efficiency in installations throughout this country and abroad.

Engineered by experts, the K-39 stays pressure tight to 60-in. of water with consistent weighing accuracy. It prevents escape of primary air into the boiler room. It's unfailingly exact, checking coal consumption to within ounces by hour, shift or week. It enables you immediately to spot and correct inefficient steaming—makes for *major savings* in fuel for stoker or pulverizer-fired boilers in all sizes of central stations and power plants.

Bulletin No. 0250 gives complete details on how and why the Richardson K-39 Automatic Coal Scale means more efficient and economical fueling. Write for it today—or ask a Richardson Engineer to survey your present methods of checking on fuel consumption. There's no obligation.

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Clifton, New Jersey

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several months and by our country's stepped-up defense program.

The first 150,000-kw unit at Ridgeland will be completed and in operation before the end of the year, and will raise the total generating capacity of the Edison system to 2,802,000 kw. A second new unit of equal capacity, now under construction, is scheduled for service late in 1951.

* * *

STONE & WEBSTER ENGINEERING CORP. has recently announced the appointment of Robert Jefferson Carter as Southwestern District Manager for the Corporation with offices in the Esperson Building, Houston, Texas. Mr. Carter succeeds Mr. A. T. Krook, recently elected President of Stone & Webster Canada Limited after nine years as Manager of the Houston office.

* * *

GENERAL REFRACTORIES CO. announces appointment of Mervin A. Fay as Assistant General Sales Manager, effective November 1, 1950. Mr. Fay has been assigned to the Research Department of the Company since 1946, as Ceramic Engineer, having previously been associated with Bethlehem Steel Company in a similar capacity.

* * *

CHESTER H. BUTTERFIELD, vice president of Manning, Maxwell & Moore, Inc., has been named vice president in charge of the Consolidated-Ashcroft-Hancock Division, it was announced recently.

* * *

CYRUS WM. RICE & CO., INC., announce the following changes in the organization: H. E. Einert, President and General Manager; F. R. Owens, Vice President and Director of Services; J. K. Rice, Treasurer and Director of Operations; E. F. Koch, Secretary and Manager of Sales. Cyrus Wm. Rice continues as Chairman of the Board.

* * *

FRANK R. SIMPSON has been appointed Director of Research and Development for The Kuljian Corporation, engineers and constructors, of Philadelphia, according to a recent announcement.

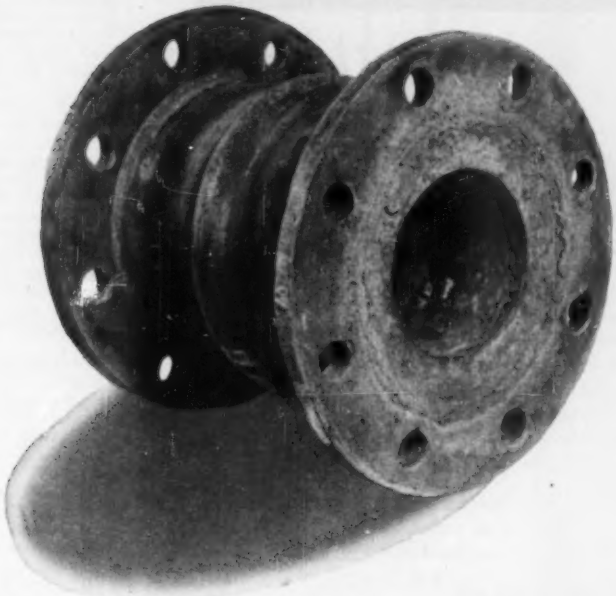
* * *

JULIAN E. TOBEY, president, Appalachian Coals, Inc., Cincinnati, Ohio, has been given the 1950 Percy Nicholls Award for notable scientific or industrial achievement in the field of solid fuels.

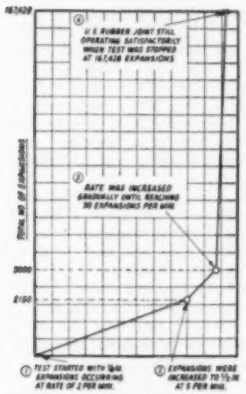
The award was presented October 24th at the Thirteenth annual joint meeting of the American Institute of Mining & Metallurgical Engineers and The American Society of Mechanical Engineers at the Statler Hotel, Cleveland, Ohio. It is the highest award sponsored jointly by the ASME and AIME.

Tobey is the ninth in a list of prominent engineers to receive this annual award which was established in 1942 in honor of the late Percy

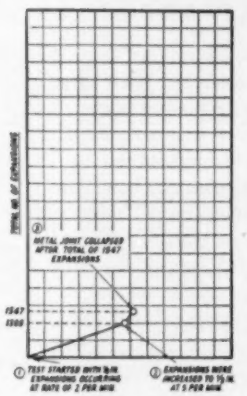
21 YEARS ON THE JOB
—and still in the pink!



Another U. S. Rubber Expansion Joint Success Story


① U.S. RUBBER JOINT STILL OPERATING SATISFACTORILY WHEN TEST WAS STOPPED AT 167,428 EXPANSIONS
② RATE WAS INCREASED GRADUALLY UNTIL REACHING 30 EXPANSIONS PER MIN.
TOTAL NO. OF EXPANSIONS
3000
2150
① TEST STARTED WITH 1/8 IN. EXPANSIONS OCCURRING AT RATE OF 2 PER MIN.
② EXPANSIONS WERE INCREASED TO 1/2 IN. AT 5 PER MIN.

Test of U. S. Rubber Expansion Joint


② METAL JOINT COLLAPSED AFTER TOTAL OF 1547 EXPANSIONS
TOTAL NO. OF EXPANSIONS
1547
1300
① TEST STARTED WITH 1/8 IN. EXPANSIONS OCCURRING AT RATE OF 2 PER MIN.
② EXPANSIONS WERE INCREASED TO 1/2 IN. AT 5 PER MIN.

Test of Metal Joint

To determine comparative endurance, a U. S. Rubber Expansion Joint and a metal joint were subjected to the vibration tests described in the above charts. The metal joint collapsed after 1,547 cycles while the rubber joint was still operating satisfactorily after 167,428 cycles. A rigorous test for shock also demonstrated the superiority of the U. S. Rubber Expansion Joint.

An iron pipe line required replacement after 21 years of carrying a chemical refrigeration material. The "U. S." Expansion Joint photographed above was used as a flexible connection on this pipe line. When removed during dismantling of the line, the joint was found to be in sound condition—in fact it had outlasted the pipe!

United States Rubber engineers can design and build joints to meet conditions involving water, brine, oils, gases, acids and other chemicals. They can make practical recommendations for their use to take care of expansion, contraction, vibration and elimination of noise transmission and provide resistance to fire. Note the graphs at left, which show how "U. S." Expansion Joints behaved in a vibration test.

"U. S." engineers will gladly discuss and make recommendations for the solution of any problems you may have. Write to address below.

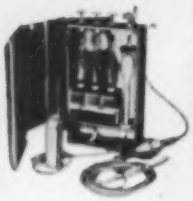
A PRODUCT OF

U.S.RUBBER
SERVING THROUGH SCIENCE

UNITED STATES RUBBER COMPANY

MECHANICAL GOODS DIVISION • ROCKEFELLER CENTER, NEW YORK 20, N. Y.

Determine Combustion Efficiency By Accurate Measurement of CO_2



by hand

HAYS PORTABLE GAS ANALYZER

Every power plant needs this handy Hays Portable Gas Analyzer or Orsat. It gives you a quick, accurate test of flue gases for CO_2—one of the best known ways to measure the efficiency of your fire. It also serves as a check on your CO_2 Recorder.

Hays offers several styles from which to choose—from the single chamber to the multiple unit that analyzes for CO_2, O_2 and CO. All sizes immediately obtainable. Send for new catalog (Publication 47-668) and the helpful booklet "The A-B-C of CO_2."

or automatic

HAYS CO_2 RECORDER

To most boiler room operators this is the dependable "stand by"—the Hays CO_2 Recorder or Combustion Meter, permanently mounted and automatic. Every two minutes throughout the 24 hours it makes a combustion analysis and records its findings on a 10-inch chart. It also records draft and flue gas temperature. The Hays Combustion Meter operates entirely by water on the true Orsat principle of volumetric measurement and chemical absorption—and is virtually infallible. Its interesting story is in Publication 47-550—send for it.

THE HAYS CORPORATION, MICHIGAN CITY 7, INDIANA

THE HAYS CORPORATION
MICHIGAN CITY, INDIANA, U.S.A.

Nicholls of the U. S. Bureau of Mines. The presentation was made by E. G. Bailey, the first man to receive the award.

* * *

To PROVIDE increased service for its expanding Canadian business, Gardner-Denver Co. is establishing a Canadian plant, officials of the company announce. The new plant will be located at Brantford, Ontario, and will be operated by Gardner-Denver Co. (Canada) Limited.

* * *

E. F. DREW & CO., INC., has announced the appointment of James Quigley, James Devine and Charles T. Monroe as laboratory technicians in the Power Chemicals Division.

* * *

MR. JAMES J. MURRAY, of the Murray Equipment Co., announces a recently signed distributorship agreement to handle Worthington Pump and Machinery Corp. Multi-V Drives and fractional horsepower belts and sheaves.

* * *

CARL W. NEDDERMAN, for 15 years affiliated with metal-working industries in an executive capacity, has been elected assistant vice president of Edward Valves, Inc., East Chicago, Indiana.

* * *

POWER CHEMICALS DIVISION, E. F. Drew & Co., Inc., has announced that Joseph H. Whitney has joined their laboratory and research staff.

* * *

WILLIAM H. MORSE has been appointed manager of the ac mechanical engineering section in the Transportation and Generator Division of the Westinghouse Electric Corporation at East Pittsburgh. Mr. Morse succeeds the late A. C. Larson.

A native of Pittsburgh, Mr. Morse was graduated from Lehigh University in 1941 with a degree in mechanical engineering. While he was in college he was elected to Tau Beta Pi and Pi Tau Sigma honor societies. He is a member of the American Society of Mechanical Engineers.

After one year's training in the Westinghouse Graduate Student Training Course beginning in 1941, Mr. Morse was assigned to the AC Engineering Department as a mechanical design engineer. Recently he developed a special synchronous-motor damper winding for starting large motors for which he has been granted a patent.

* * *

THE APPOINTMENT of John E. Stevens, Jr., as assistant to the president of Edward Valves, Inc., East Chicago, Ind., has been announced by W. F. Crawford, president.

* * *

HAROLD K. BECK has been appointed commercial vice president, in addition to his present post as manager of the Worthington office of Worthington Pump and Machinery Corp.

3 steps to successful

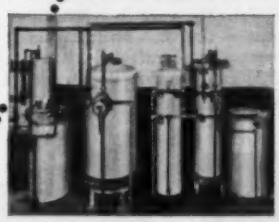
ION EXCHANGE PERFORMANCE

Whether it is a simple greensand softener or a large demineralizing plant, these three essential steps are necessary to produce an ion exchange installation which:

- is easy to operate
- requires low chemical regenerating costs
- yields uniformly dependable performance

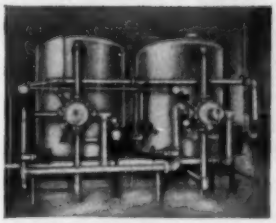
LABORATORY RESEARCH

Graver chemists and technologists are continually evaluating the performance of many ion exchangers to determine the optimum operating conditions for each. As a result of this work the specific advantages of more than forty available Graver ion exchangers can be effectively applied to a wide range of processes.



PILOT PLANT OPERATION

Graver development engineers regularly conduct tests on small scale pilot units operating under simulated plant conditions. These tests serve to check laboratory experiments and to work out problems in mechanical design. This assures dependable operation of the ion exchange equipment under actual service.



COMMERCIAL EXPERIENCE

A background of thirty years' successful commercial experience is reflected in the design of Graver equipment. Graver chemical engineers have pioneered the commercial application of many new ion exchange processes. Dependable service is assured as a result of this experience.

Write for the following reprints:

"Operating experience with Resin Zeolites on the Hydrogen Cycle"

"Present Practices in the Use of Ion Exchangers in Water Treatment"

"Silica Removal by a Practical Ion Exchange Process"

GRAVER

GRAVER WATER CONDITIONING CO.

216 West 14th Street, New York 11, New York, U.S.A.

GW-488

A DIVISION OF GRAVER TANK & MFG. CO. INC. EAST CHICAGO, IND.

DRAFT FANS

GO

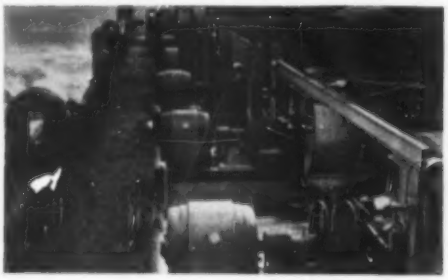
on GREEN

A Big Draft Job Handled Capably by Green Fans

Twenty-four large Green Fans take care of a heavy draft load at the Venice (Illinois) Plant of the Union Electric Co. of Missouri. Each of six boilers has two sets of Green Fans, each set consisting of one induced draft fan and one forced draft fan coupled to one motor as a unit. With the heavy demands on this station, all boilers are usually in service continuously, thus throwing an unrelenting burden on the fans.

Engineers whose responsibility it is to recommend or accept draft fans for large power plants certainly want efficiency and low operating costs. But they don't overlook the maintenance and replacement angles. They want the sound designs of competent experienced fan engineers. They also want the care in construction that is found in shops of a company that has built up an international reputation as the "authority" on draft fans. They know that such a company will not tolerate sloppy shop work.

Green is this authority on mechanical draft fans.



Have You a Copy of Our Fan Bulletin No. 168? If not, we shall be glad to send you one.

THE GREEN Fuel Economizer COMPANY INC.

BEACON 3, NEW YORK

ECONOMIZERS • FANS • AIR HEATERS • CINDERTRAPS

JOHN W. MCNALL has been appointed division engineer of the research department of the Westinghouse Lamp Division, Bloomfield, N. J. E. G. F. Arnott, research director, said Dr. McNall will direct the electron emission, gas discharge and physical measurements sections of the department.

* * *

THE AMERICAN IRON AND STEEL INSTITUTE held its Chicago Regional Meeting on December 1, at the Drake Hotel in Chicago. As indicated by Walter S. Tower, President of the American and Steel Institute in his opening address at this meeting, the American steel industry has enough capacity to meet the war demand and at the same time support a good civilian economy. At the present time some 13 lb of manganese is required per ton of steel. Some of this is obtained from Russia and some from India and steps are being taken in Washington to assure a continuity of supply of this vital element.

Other subjects discussed at this meeting were, air pollution in the steel industry, pressure operation of blast furnaces, blast furnace sintering practice and the continuous annealing of strip steel. Clarance Randall, President of Inland Steel Co., surveyed the European steel situation.

TOMAHAWK

(Continued from page 57)

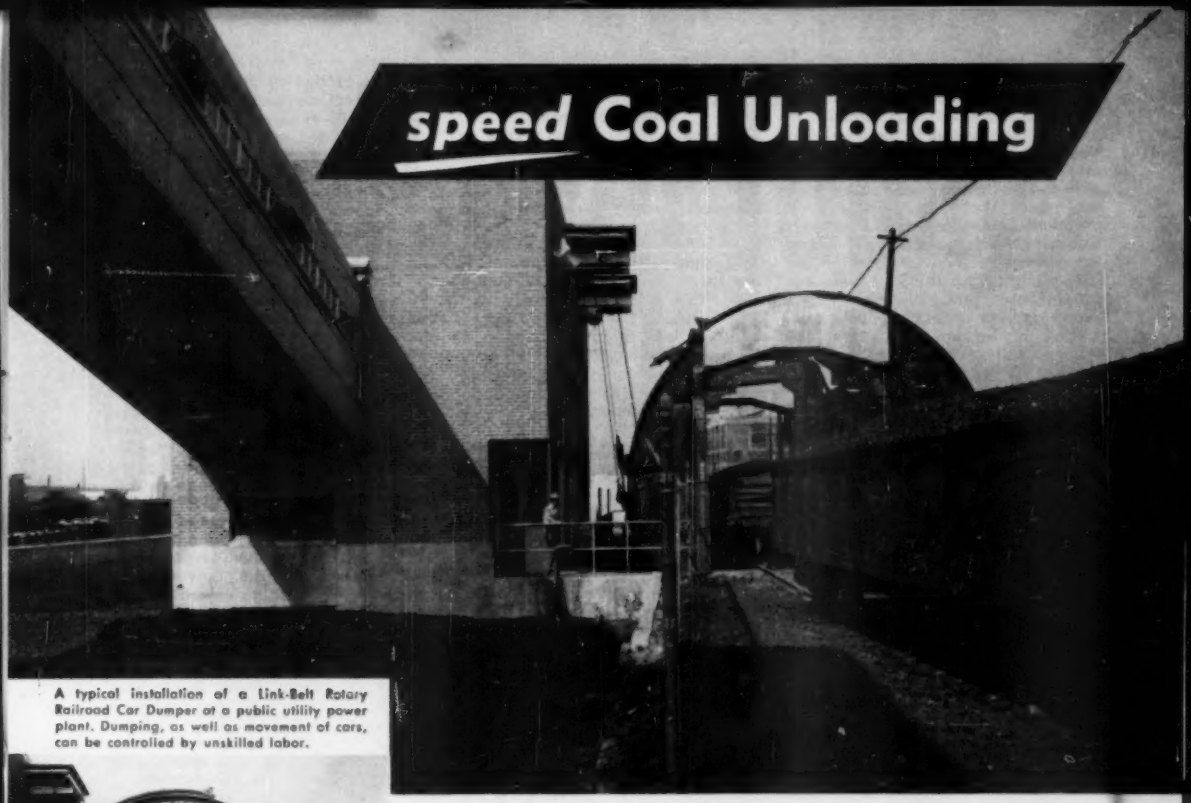
into the lower portion of the raw water heating compartment at Point 7.

Since the steam entering at Point 1 is under a higher temperature than the surrounding slurry, a portion of the steam bubbles will condense and give up their heat to the slurry as they rise in the center tube. The remaining energy in the steam is converted first to mechanical energy of the moving slurry and this energy finally, of course, dissipates into heat. Therefore, none of the energy of the steam used for lift action is actually lost since all eventually goes into heating of the water in the hot process tank.

The effluent from the Hot Process Lime and Soda Ash Softener flows into a secondary Phosphate Softener. Here, the make up water is reduced to zero hardness with a slight excess of phosphate being maintained. Built in as an integral part of this softener is a tray type, deaerating section for condensate deaeration and a storage chamber for the condensate. The treated make up water flows by gravity through filters and then mixes with the deaerated condensate before being pumped to a 14 ft 6 in. diameter by 33 ft 0 in. long feedwater storage tank. Both softeners and the feedwater storage tank are maintained at 6 lb steam pressure.

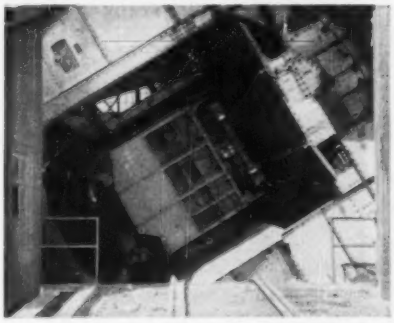
Activated silica and alum are pro-

speed Coal Unloading



A typical installation of a Link-Belt Rotary Railroad Car Dumper at a public utility power plant. Dumping, as well as movement of cars, can be controlled by unskilled labor.

Thorough and immediate dumping is assured by completely inverting the car. Sturdy construction of all parts provides long life in this service with little maintenance and eliminates the necessity for alternate, stand-by equipment.



The unusual flexibility built into the Link-Belt Rotary Railroad Car Dumper permits the unloading of any size of all types of open-top cars without any adjustments by the operator.

The Link-Belt Rotary Railroad Car Dumper fits into today's requirements for economy and speed in coal unloading at power plants. Any size of standard open-top railroad cars may be handled by this remarkably flexible and efficient machine which unloads a car by turning it upside down, assuring rapid and complete discharge, winter and summer. The dumper is so well balanced and counterweighted that its operation requires a minimum of power. A dumping cycle of a minute and a half is usually realized with a 40 horsepower motor, and more rapid operation can be accomplished with larger motors. The number of cars that can be dumped in a given time depends upon the switching and track facilities for delivering the loaded cars and removing the empties. Some installations handle 40 or more cars an hour. With such capacity no more than the one track hopper is required at most plants, even the largest, but the inherent economies of this type of unloading apparatus bring it within the reach of those with modest capacity requirements.

Because the Link-Belt Rotary Railroad Car Dumper is adaptable to existing and new plants, it will fit into your plans for improving coal handling methods. Our engineers will be glad to give you complete information concerning this machine and other coal handling equipment. Ask our nearest office.

12,150-A

LINK-BELT

COAL HANDLING EQUIPMENT

LINK-BELT COMPANY

Chicago 9, Indianapolis 6, Philadelphia 40, Atlanta, Houston 1, Minneapolis 5, San Francisco 24, Los Angeles 33, Seattle 4, Toronto 8, Johannesburg. Offices in Principal Cities.

portioned to the accelator by Milton Roy pumps, operating on a time cycle which is controlled automatically by the flow of water to the accelator. The lime-soda ash slurry is pumped into the primary softener by an Ingersoll-Rand centrifugal pump with the amount being established by a proportioner in the Infilco lime-soda ash mixer. The phosphate is fed to the secondary softener by a Milton Roy pump. Both the lime-soda ash proportioner and the phosphate pump operate on a time cycle controlled by the flow of water to the hot process softener.

Since its installation, this feedwater treating system has been in continuous operation at about its rated capacity of 72,000 lb per hr of raw water.

Boiler Feed Pumps

Two sets of boiler feed pumps deliver the feedwater to the high and low pressure boilers. The two boiler feed pumps for the new boiler are Ingersoll-Rand 6-stage, centrifugal pumps rated at 450 gpm, 1816 ft head. One is drawn by a 300-hp, 3600 rpm, 4160-v, G-E motor and the other by a 300-hp, G-E- turbine. This is the turbine shown in Fig. 5, taking 150 lb steam and exhausting into the 50 lb header.

Electrical Generation

The new turbine generating unit is a 6250 kva, General Electric Co. machine, comprised of a 16-stage double extraction condensing turbine direct connected to a 4160 v, 3-phase, 60-cycle generator with direct connected exciter. The turbine is supplied with steam at 625 psi, 700 F and exhausts into a C. H. Wheeler, divided water box, surface condenser. The steam end of this turbine is shown in Fig. 3. The generator is built with a closed cooling system with built-in air cooler.

Two control boards are provided — one, the turbine gage board and the other, the electrical control board. The electrical control board, shown in Fig. 8, consists of three panels with a swinging bracket, designed and furnished by General Electric. All switches and circuit breakers are electrically operated from a 60-cell, 120-v Gould storage battery. This battery is located along one side of the Turbine Room wall, as shown in Fig. 2.

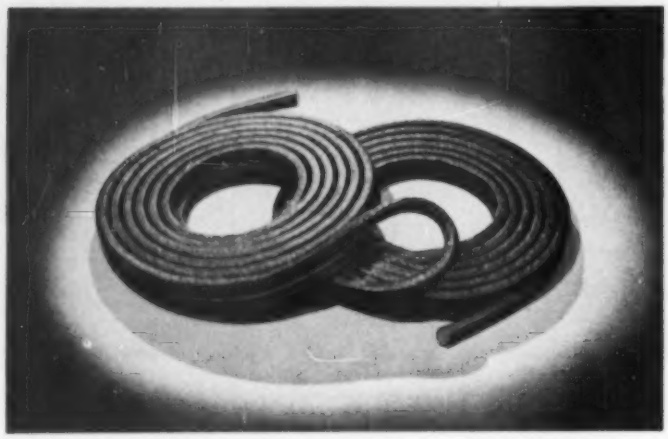
The turbine gage board is located alongside the turbine. In addition to the turbine gages, this carries all the steam flow recording meters; the pressure reducing valve control stations; and the controls for the desuperheating stations of which there are four. This panel board is also shown in Fig. 2.

A 15-ton Shaw-Box crane is provided to handle the machinery at times of overhaul. The Turbine Room basement contains the condensing equipment and miscellaneous pumps and air compressors.

Conclusion

Since this new power plant was placed in operation in July 1949 it has operated continuously with the mill. Practically no trouble was encountered placing this unit in operation, and its smoothness of operation has well justified the care that

Fig. 11. To prevent coal from hanging up in the outlets of the overhead coal bunker, this distributing cone, devised by Mr. Hoeft, is installed just below the discharge from the flight conveyor above



GOODALL STYLE A-444
SQUARE BRAIDED ASBESTOS
PACKING

A *quality* packing for centrifugal or rotating pumps handling hot or cold water, steam, brine, oils, and various acids. Made of long-fibre asbestos yarns, square plaited like wax, with each strand thoroughly graphited and lubricated. The method of braiding gives a soft, resilient finish that will not carbonize or harden, thus insuring minimum friction, with reduced sleeve and shaft wear. Available in a complete range of sizes.

Contact Our Nearest Branch for Details and Prices

GOODALL RUBBER COMPANY

GENERAL OFFICES, MILLS and EXPORT DIVISION, TRENTON, N. J.

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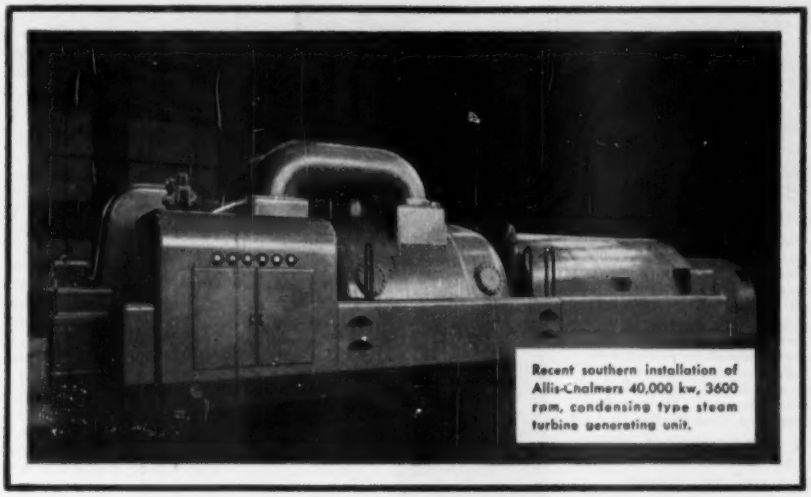
Est. 1870

For Power Today, Industry Relies on

STEAM TURBINE GENERATORS!



Recent southern installation of Allis-Chalmers 40,000 kw, 3600 rpm, condensing type steam turbine generating unit.

SOME CALL THIS THE ATOMIC AGE, but steam is more than ever the prime mover in American industry. Steam, driving the modern steam turbine and generator, now supplies over 70 percent of U. S. electric power!

And every year sees more steam turbines going on the line . . . turbines with design still further perfected, operating more efficiently and for longer periods between shutdowns. At Allis-Chalmers, turbine design is progressive, with advances in materials and know-how immediately being translated into better machines.

As a manufacturer building large central station turbine generator equipment, A-C is an important source of steam turbines in all types and combinations. In the larger ratings, A-C has in service large single shaft condensing units to 150,000 kw and topping turbines to 50,000 kw.

In addition to concentrating on mechanical features, Allis-Chalmers builds steam turbine generators with an eye to functional and attractive appearance (see photo above).

When you plan the installation or expansion of a steam power plant, consider Allis-Chalmers. Put its 80 years of steam power experience to work for you. Offices in all major cities. A-3213

ALLIS-CHALMERS, 953A SO. 70 ST.
MILWAUKEE, WIS.

ALLIS-CHALMERS

TURBINES & GENERATORS | CONDENSERS & PUMPS | SWITCHGEAR & BREAKERS | MOTORS & CONTROL | TRANSFORMERS | WATER CONDITIONING

World's Widest Range of Power Plant Equipment

went into its design by the Consulting Engineers, Helmick, Edeskuty & Lutz of Minneapolis, Minnesota.

The new boiler has been operating under an average steam load of 94,000 lb per hr at 85 per cent efficiency. The turbine generator has been operating at an average load of 4300 kw with a heat rate of 10,300 Btu per kw.

The plant is operated under the supervision of the Power Plant Superintendent, by a crew consisting of a Fireman, Fireman's Helper and Turbine Operator who work around-the-clock on four 6-hr shifts and one coal man who works days only.

UNDERGROUND HYDROELECTRIC PLANTS

(Continued from page 59)

added advantage and not the primary reason.

Rusck and Westerberg state that cost of underground hydroelectric plants now under construction in Sweden is about $80 per kw maximum output for stations of 100,000 to 300,000 kw. This is based on 1949 prices at exchange rate of 5.18 Swedish kroner per $1.

Maintenance costs for tunnels and rock walls and roofs are lower than for corresponding surface plants where concrete is used. Depreciation too is lower, for rock has much longer life than concrete.

In Sweden, engineers figure on annual maintenance cost and depreciation of 1 per cent of construction cost for rock work as against a corresponding figure of 1.7 per cent for concrete.

Operating Factors

The authors state that there are no essential differences in operation of an underground plant and of a surface plant and no direct disadvantages. In large plants, two operators are normally on duty per shift, whether the plant is above or below ground. An operator in an underground plant does not see the sun during his shift, but apart from this there should be little difference between underground and surface operation—and even in some surface plants he might not see the sun either.

Climatic conditions are more constant underground. There has been no reported tendency for operators of underground plants to apply for discharge or transfer to surface plants because of psychological factos. Operators have the same working hours, holidays and social advantages as those in surface stations.

Italian Plants Built in Caves

Interesting details of hydroelectric plants built in caves in Italy have been given by Ritter[2], as reported in *Electric Light & Power*. He gives data on power plants in caves of the Societa Adriatica de Elettricita in Italy, which has ten years' operating experience in this particular field. All these plants are built as a unit. Each unit consists generally of a machine room, the wells for the turbines under the machine room, the control desk in front of and higher than the machine room, separated from this by a wide glass pane. There are also small tunnels for bus bars, cables, etc., which connect the machines with the step-up transformers which are normally outside the cave. Figure 2 shows one of these typical installations.

Ventilation

Necessities of good conservation of the electric materials require that the atmosphere be well ventilated and as dry as possible. Therefore the Societa has adopted constructions insulated from the walls of the cave by thick fillings, so that infiltration of water is prevented.

It was also thought that ventilation would be automatically taken care of by the wide tunnel which had to be built for bringing the machinery into the cave and carrying out the materials which had been dug out. In practice these tunnels did not always provide an effective circulation of air everywhere, and it was necessary to build particular installations for rooms which were not part of the principal ventilating circuit. In these rooms, air was stagnating, so that the operating

The NOSE KNOWS THE DIFFERENCE

Chlorinators should be seen but not smelled. Builders Visible Flow Chlorinizers are completely free from tray-produced chlorine gas odors. These efficient chlorine gas feeders are a welcome addition to any plant or process where chlorination is required. They work safely, accurately, dependably — *without the nuisance of offensive chlorine odors!* That's because fresh water is constantly supplied to the tray, drawn into the injector, and then delivered to the point of application.

BUILDERS CHLORINIZERS GIVE YOU THESE EXTRA FEATURES:

- no "ice" in vital control parts
- accurate Sightflo chlorine rate indicator
- visible and positive evidence of vacuum and flow
- long life chlorine control valve
- no tray-produced chlorine odors
- powerful, spring-loaded shut-off valve

For engineering information and Bulletins, address Builders-Providence, Inc., (Division of Builders Iron Foundry), 385 Harris Ave., Providence 1, R. I.

Builders makes a complete line of flow meters and controllers for liquids, steam, air, gas, and dry materials . . . mechanical and differential . . . including The Venturi Meter and Chlorinizers (chlorine gas feeders).

Model DVSX

Model CVS

Installation at R. I. State Prison, Howard, R. I.

BUILDERS PROVIDENCE
Instruments

It's new . . . inside and out

WARREN *Cradle Mounted*

COMPACUNIT

? Do you want to handle corrosive materials that might injure the motor on a close-coupled pump?

? Do you want to use a standard or special motor or turbine?

? Do you want to use a V-Belt drive that will permit a wide range of speeds?

. . . then a Warren Cradle Mounted Compacunit could be the answer. This versatile, efficient and sturdy pump is built to "stand the gaff"... and the price lower than you might expect for a quality product of this kind.

Sizes: 1", 1½", 2", 3"
Capacities: 5 to 450 G. P. M.
Heads: 15 to 500 feet
Materials: Standard, All Iron, All Bronze, or special to meet your requirements

Why not check this pump against your next pumping job, if within the indicated operating conditions? Ask for bulletin #242

P-21

WARREN STEAM PUMP COMPANY, INC. WARREN, MASSACHUSETTS

WARREN Compacunit PUMPS

Remove Oil...

FROM BOILER AND PROCESS WATERS THIS NEW LOW-COST WAY!

What it is —

Filtration with Sorbo-Cel is a simple, low-cost method of removing emulsified oil from water. In plants using steam generating equipment, it is proving an especially effective and economical means of obtaining oil-free condensate for boiler feed. It also provides a practical solution to other oil-contaminated water problems, such as the water used in pumps, condensers, cooling systems, moving driers, etc.

How it works —

The method is similar to that used in other conventional industrial filtration operations. A small amount of Sorbo-Cel (a specially processed diatomaceous silica powder), is added to the water to be filtered. This is then pumped through a pressure filter where the oil globules are adsorbed by the specially treated Sorbo-Cel particles. Both are retained on the filter screen, the filtered water alone passing through. Any type of pressure filter having a metal screen and capable of operation at a pressure differential of 30 psi or more may be used.

What its advantages are —

Sorbo-Cel filtration is fast, economical and efficient. It assures virtually complete removal of oil, as well as suspended solids such as rust, scale, clay, etc. Large volumes of water are filtered in a relatively short time, yet total costs (including both material and operation) range from only 1¢ to 5¢ per 1000 gallons of water filtered.

For further information about Sorbo-Cel filtration use the coupon below.

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PG-12

personnel faced bad ambient conditions.

The principal ventilating circuit is composed of:

(a) Intake of fresh air through the entrance tunnel;

(b) Distribution to the machine room;

(c) Expulsion of the warm air to the outside, by means of a vault tunnel, with helical fans.

Since the machinery is normally ventilated in a closed cycle and water-cooled, the heat which must be taken care of is only the heat radiated by the exterior surfaces and by the exciters. In general, natural ventilation is sufficient for most of the year, and fans are required only in the summer period, or when the machines are overloaded.

The operating room is excluded from this principal ventilating circuit, and at first a special air conditioning unit was built for it. Later it was found that this air conditioning unit was unnecessary, and a special ventilating circuit was built for the operating room, in parallel with the principal circuit.

At first the intake of air was under the control desk, and a fan in the room ceiling removed the hot air. This system was not satisfactory, because the control desk generated abundant heat through the resistors, and the air heated up the room before it was removed. Therefore, the ventilating cycle was inverted, by setting the intake of fresh air in the ceiling, and by removing the hot air beneath the control desk.

Results were excellent, because a 0.15-kw centrifugal fan was found to be sufficient for an operating room of about 8500 cu ft in volume.

For the turbines, in general, natural ventilation is sufficient, since they are in communication with the tunnel for the discharge of water. For the plants in which the bus bars are built in the main entrance tunnel, the principal ventilating cycle should be inverted, to avoid preheating of the fresh air.

The temperature inside the plants tends to remain constant despite external changes during the day; the variations during a whole year are within an interval of 6 C (10.8 F). Figure 3 shows measurements made in the plant of Cencenighe.

Relative humidity inside is generally a little lower than the humidity outside. Tests also have shown that no carbonic acid, ozone, or other dangerous or unpleasant gases were present in the caves.

Illumination

Illumination of underground power plants presents particular problems, because of the diversity of the rooms to be lighted, and the necessity that the personnel have excellent visibility of all the machinery and control apparatus, which are at different distances and at various angles of incidence. Average illumination of these rooms

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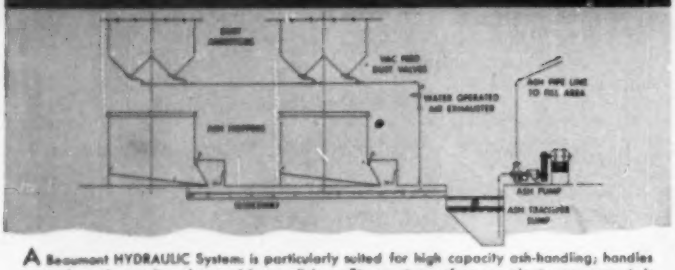

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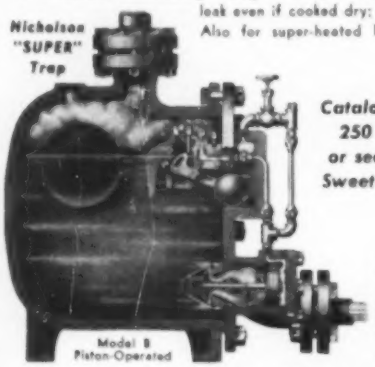

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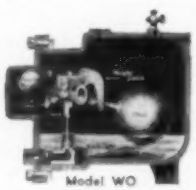

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should be about 50 lux. For smaller rooms it is always convenient to have indirect lighting, which compensates for the lower efficiency with a good surface distribution of the source of light and with a reduction of the possibilities of glare. This system, used in the control rooms, has given good results.

Illuminating surface is the ceiling, painted in clear tones, which diffuses light uniformly on the walls, which are made of panels of uniform color. To avoid glare from meters, these should be installed vertically and have a flat front glass. Also lighting of the luminous circuits used on the control desks should not be too bright. Luminous circuit diagrams in relief are to be preferred. They come out well with low illumination and show the situation of the circuit even if their internal light source should fail.

If the machine rooms are sufficiently high; projectors may be installed directly in the ceiling; otherwise they must be boxed in the ceiling to avoid glare. In this way, with 2 kw installed power it was possible to obtain 25 lux on the floor of a machine room 36 x 90 x 42 ft.

Fluorescent lighting also has given good results: with 50 lamps, of 2.5 kw power, an illumination of 50 lux was obtained on the floor of a machine room of 7800 sq ft surface and 42 ft high.

The emergency lighting system must be as powerful as the regular one, because it will be called on when the personnel needs to read all meters quickly and accurately.

HELPFUL BULLETINS

(Continued from page 35)

capacities to 16 gpm are introduced in Form 7233, 16 pp. Fully illustrated with photos of assembly and parts and sectional views, it discusses pumps' radial and axial balance, sealing arrangements and mountings. Ingersoll-Rand Co.

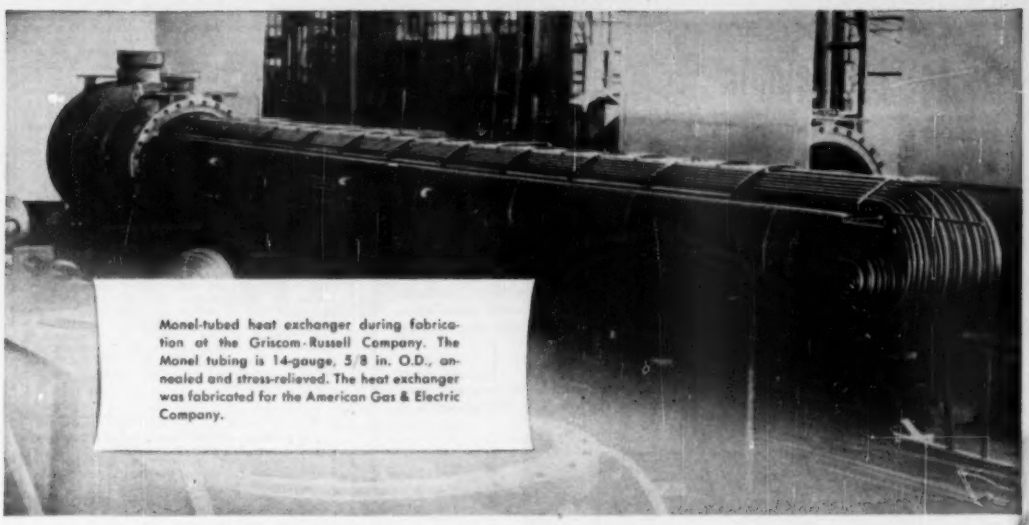
WATER FILTRATION, SOFTENING

130 **Modern Filtration Equipment**—Methods and equipment for industrial water filtration are illustrated and compared in 20-pp Bulletin 691. Pressure filtrations systems are diagrammed in color to show varied applications. Text discusses origins of filtration practice and the development of today's filter media and backwashing techniques, including continuous automatic backwashing. Cutaway views, operating data and piping suggestions for single and battery installations are provided. R. P. Adams Co., Inc.

131 **Softener for the Small Plants**—Publication 4505 illustrates and describes water softening apparatus for small boiler and industrial plants, laundries, hospitals, where less than 100 gpm of softened water are required. Two size groups are offered, each in single or double units with greensand, synthetic gel and resinous type zeolite material. Drawings, dimensions and capacities are shown. Cochrane Corp.

BLOWERS

132 **Axial Flow Blowers**—In this 6-pp illustrated bulletin are described axial flow blowers of both turbine-driven and motor-driven types. Gives capacity and dimensional data, operating range and specifications on both types. Also describes company's draft inducers and dual drive forced draft blowers. L. J. Wing Mfg. Co.



Monel-tubed heat exchanger during fabrication at the Griscom-Russell Company. The Monel tubing is 14-gauge, 5/8 in. O.D., annealed and stress-relieved. The heat exchanger was fabricated for the American Gas & Electric Company.

Higher pressures obtained with *stress-relieved* Monel tubing

Cold drawn, stress-relieved tubing has significantly higher mechanical properties than annealed tubing of the same composition.

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In practical terms, this means that boiler feedwater heaters can be designed for higher operating pressures and temperatures *without increasing tube wall thicknesses.*

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Cold drawn, stress-relieved *Monel®* tubing offers still other advantages in heater tubing applications. *Monel's* high resistance to corrosion inhibits scale formation. Its superior hardness effectively reduces erosion and cavitation damage. And—an important asset—*Monel* can be welded directly to steel by conventional techniques.

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133 **Pressure Blower**—Described as a new concept in air-moving equipment is the direct drive axial flow pressure blower featured in this 34-pp collection of engineering data sheets. This blower which has its motor in the hub is for volumes to 100,000 cfm and pressures to 4 in. wg. Discusses general construction features of the blowers and covers standard, enclosed, and reverse direct-drive units, also belt-drive units. Fully illustrated. Includes dimensions, installation tips. The Moore Co.

METALS

134 **Chart on Metals for Corrosive Services**—Just name your poison, corrosive material that is, and you'll find it among the 350 listed in this selection chart. List includes corrosive media common to a wide range of industrial jobs and covers their use with carbon steel, three of company's alloys and certain other alloys, showing whether each metal is recommended, suitable or unsuitable for use. Since the metals are arranged in order of cost it's also easy to select the one that handles your particular corrosive most economically. The Cooper Alloy Foundry Co.

135 **Hard Metal Castings**—Believed to be the first publication on castings made of hard metal alloys, this 16-pp booklet offers helpful information on their use, available types and how to order them. Filled with unretouched photos of rolls, bushings, bearing boxes, cylinders and other specimens, it includes approximate prices and an explanation of why the higher first cost of these made-to-order castings is justified in cases involving severe abrasion, corrosion, high temperatures. Stoody Co.

COAL AND ASH HANDLING

136 **Coal Scales**—Bulletin 0150, 12 pp, gives up-to-date information on company's automatic coal scales. Explains how they work and how they're built, describing and illustrating major parts. Includes working drawings of a stoker installation and pulverizer installation. Richardson Scale Co.

137 **Ash Handling Systems**—This 24-pp illustrated booklet offers technical information on hydraulic and pneumatic ash and flyash handling systems. Compiled in question and answer form, it discusses elements and advantages of various systems and disposal schemes. Schematic drawings of arrangements under specific conditions and diagrams of basic arrangements are included. Beaumont Birch Co.

OTHER EQUIPMENT

138 **Test Data on High Temperature Oils**—The results of an extensive research program on high temperature lubrication are told in Bulletin 2-416, 4 pp. This well illustrated folder completely describes the testing procedures used in setting up three series of oils to meet high temperature conditions up to and even over 500 F. These include straight mineral oils, semi-synthetic lubes, and colloidal graphite in light carrying oil. E. F. Houghton & Co.

139 **Refractory Hung Arch**—Bulletin 950, 4 pp, explains how company's refractory hung arch not only hangs — but moves — like a pendulum. It describes the case of installation and positive locking arrangement between lower and upper tiles to prevent disengagement in service. Illustrates rugged load tests given this double hung arch on both its load bearing qualities and strength of interlock. Geo. P. Reintjes Co.

140 **Fiberglas Bibliography**—This is the new, 88-pp third edition of a volume of annotated references to selected articles on Fiberglas products which have appeared in the nation's press. Uses of Fiberglas products documented in the book include such applications as refrigerating equipment, water heaters, forced warm air furnaces, reinforced paper, reinforced hose, wire and cable, insulated shipping containers and storage batteries. Includes indexes of publications cited, authors and applications and uses. Bibliography is available without charge to power engineers, engineering students. Owens-Corning Fiberglas Corp.

(Continued on page 126)

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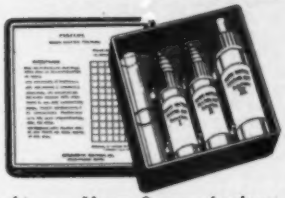

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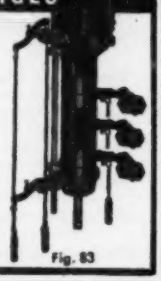

Fig. 83

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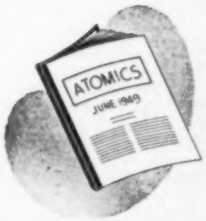

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For fast, easy rolling . . .

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Use them to re-roll old tubes or install new ones. Precision manufactured Wilson-Dudgeon Tube Expanders insure solid seating, easy rolling. All sizes, in flaring and non-flaring types, available.

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THOMAS C. WILSON, INC., 21-11 44th AVENUE, LONG ISLAND CITY 1, N. Y.

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WILSON-DUDGEON TUBE EXPANDERS

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AIR CONDITIONING ENGINEERS: At least 7 years' experience in selection and operation of heating, air-conditioning, ventilating and refrigeration equipment. Well versed in the theory of thermodynamics, fluid flow and heat transfer. For consulting evaluation, and economic operation services. Must be graduate.

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Give experience, education, age, references, personal history, salary received and salary expected. Please be complete and specific.

All inquiries will be considered promptly and kept confidential.

E. I. du Pont de Nemours & Co.
(Inc.)
Engineering Department Personnel
Wilmington 98, Delaware

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141 Pneumatic Sewage Ejector—Illustrated Bulletin S-30 describes a pneumatic or compressed air ejector developed to overcome and eliminate cleaning of screens and pumps, and discusses the ejector's advantages in terms of efficiency, economy and better sanitation. Operating principle is explained and illustrated by piping diagrams showing snap action air valve, electrode controls and float switch. Capacities, dimensions included. The Blackburn-Smith Mfg. Co., Inc., Condenser Service and Engineering Co., Inc.

142 Fundamentals of Hydraulics—Technical Bulletin B-4 is a newly revised 44-pp guidebook covering essential information on hydraulic systems, maintenance, trouble-shooting and selection of proper fluids. Besides offering well-organized reference data to engineering personnel, this book is suggested as a training manual for maintenance supervisors, operators and apprentices. It features specially prepared phantom and cutaway drawings illustrating functions of basic types of valves, pumps, hydraulic motors, torque converters. A unique system of captioning shows the function of each component part. Please give your title when requesting this book; extra copies are available for your staff if you ask for them. Sun Oil Co.

143 Tube Rolling Control—A precision method of uniformly expanding condenser and heat transfer tubes is presented in this 8-pp bulletin. Describes and illustrates the control unit and three different motors, giving operating instructions for each. Crane Packing Co.

144 Boiler Seam Saver—Described in this circular is a refractory tile attachable in sets by bolts and hangers to the seams of riveted HRT boilers to insulate the lapped edges from fire-cracking and oxidation. Illustrations show how protector is used, text stresses its efficiency and safety advantages. Sizes, directions for use in special conditions included. National Boiler Protector Co.

145 Small Cooling Towers—Illustrated Bulletin 44, 4 pp, announces a line of atmospheric spray cooling towers for small water cooled air conditioning and refrigeration condensing units. Engineering data included covers tower specifications, tables of dimensions and weights, selection tables, and tables showing pressure drops of water in pipes of various diameters and pressure losses due to pipe fittings. Binks Mfg. Co.

146 Continuous Centrifuge—This 8-pp bulletin describes a centrifuge for the fast, continuous and economical separation of liquids from solids, and of immiscible solutions. Covers both screen and solid bowl type units, providing illustrations, specifications and dimensions. Also gives data on a continuous demulsifier. Centrifuge Mechanical Equipment, Inc., Condenser Service and Engineering Co., Inc.

147 Big Little Vacuum Cleaner—Construction and operating details on a small portable vacuum cleaner incorporating heavy-duty features of the larger industrial machines are provided in illustrated Bulletin A-814, 4 pp. The cleaner is a 1½ hp machine which operates a 35-ft cleaning hose, and is made with a dust container big enough for continuous service, dust separator fitted with four inverted type filter bags, a quick-acting lever release on the container. Air Appliance Div., United States Hoffman Machinery Corp.

148 Need An Extra Hand?—Bulletin 600, 2 pp, introduces a magnetic holder for use with test meters, trouble lights and the like. Photos show how this handy gadget holds light in place while worker has both hands free for the job, gives specifications, prices. Enco Mfg. Co.

149 Services for Your Plant—Bulletin 1.19.87 is a 16-pp illustrated booklet covering company's five divisions and their scope; chemical, petroleum, natural gas, power and equipment. Tells firm's work in the fields of design, engineering, construction, process coordination and equipment manufacturing and includes photos of typical projects, plants and equipment installations. J. F. Pritchard & Co.

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WANTED — Mechanical Draftsman with piping layout experience in connection with large power plants. State age, experience, and salary desired. Reply to Chief Design Engineer, Duke Power Company, P.O. Box 2178, Charlotte, N. C.

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4000 K.W.

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Booths 46 and 47

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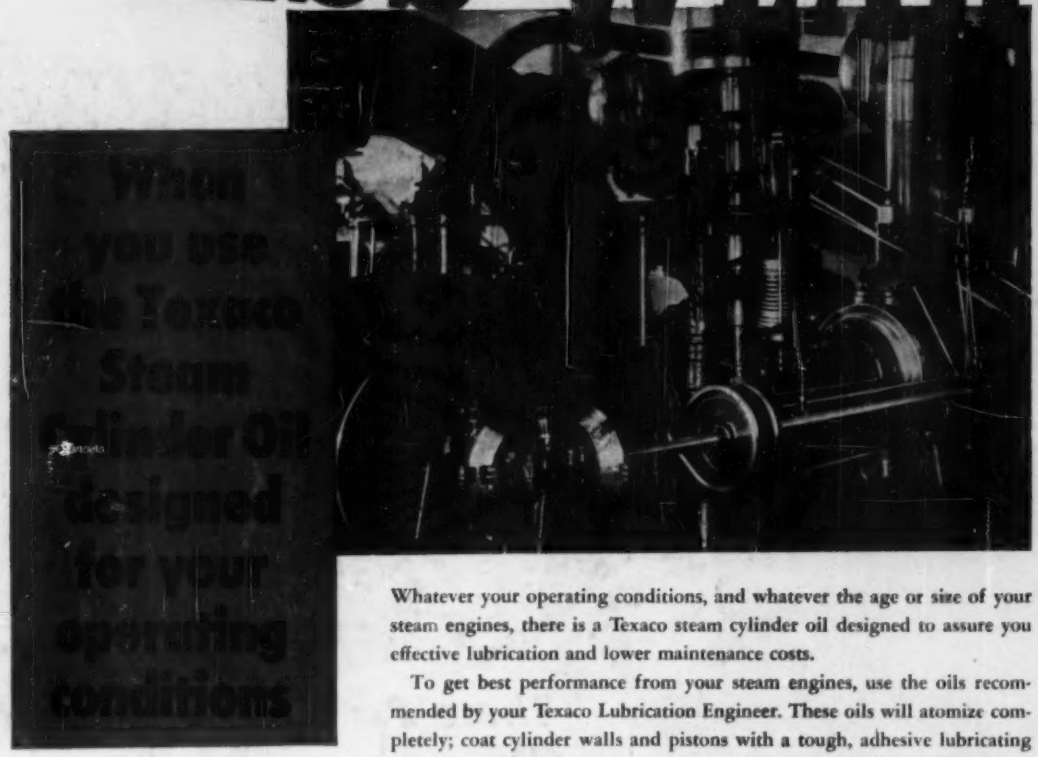

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